Issue 5. October 2015
ISSN 2052-5273

The Marine Biologist

The magazine of the marine biological community

Focus on Asia

The Marine Biological Association of India

The Unorthodox Whales of Sri Lanka

Hope after the Japanese tsunami

Plus

Is marine management an oxymoron?

The origin of nervous systems

Dreaming of a digital ocean

THE MARINE BIOLOGICAL ASSOCIATION
Est. 1884
Incorporated by
Royal Charter 2013

A new species of jellyfish | Little-known giants of the plankton
Guide to zooplankton | Young Marine Biologists

The Marine Biologist
The magazine of the marine biological community

Editorial Office

Editor Guy Baker
editor@mba.ac.uk
+44 (0)1752 633244

Executive editor Matt Frost
mafr@mba.ac.uk
+44 (0)1752 633334

Editorial Board Guy Baker, Kelvin Boot, Matt Frost, Paul Rose, Mike Thorndyke.

Membership Alex Street
alexa@mba.ac.uk
+44 (0)1752 633253
www.mba.ac.uk/membership

Correspondence
The Marine Biological Association
Citadel Hill, Plymouth, PL1 2PB, UK

The Marine Biologist is published by the Marine Biological Association, Registered Charity No. 1155893

ISSN number: 2052-5273

Submissions
We welcome submissions of original and relevant material, letters and responses to published articles. For guidance, please see the magazine website at **www.mba.ac.uk/marinebiologist** or contact the Editor.

Est. 1884
Incorporated by Royal Charter 2013

www.mba.ac.uk

Editorial

Welcome to *The Marine Biologist* magazine. We always strive to include interesting and illuminating material from all over the world and in this 'Asia edition' we hear from marine biologists in India, Sri Lanka and Japan – see below.

Marine biologists are a diverse community, but does our focus on one realm mean we are more likely even than other scientists to stay in our salty 'silo'? As Murray Roberts says on page 39, describing the new Lyell Centre, "we cannot do our best work as marine biologists in isolation". Clearly, we need to maximize opportunities for collaboration at the boundaries of disciplines – a theme for a future edition, perhaps.

Also in this edition: Pawel Burkhardt explores the origin of nervous systems, we dream of a digital ocean and discover resources such as a new plankton guide and an app to help tourists enjoy unfamiliar fish. Science and politics is rarely a harmonious mix, particularly when it comes to marine protected areas. The practical and moral case for the creation of large marine reserves in tropical shallow marine habitats is made (p. 16), and we look at a new book which questions the efficacy of marine reserves as a fisheries management tool (Reviews, p. 36).

MBA members hail from many countries (currently 44), including India. I am delighted to hand this editorial over to the Secretary of the the Marine Biological Association of India (MBAI), Dr. K. Sunil Mohamed.

With 3 million Indians directly and indirectly dependent on marine fisheries, knowledge of marine biology of the seas around India is of the utmost importance. India accounts for less than 0.25 per cent of the world's total coastline; however, 171 million people live in India's coastal districts (approximately 5 per cent of the world's coastal population and 14 per cent of India's total population). Therefore, it is not surprising that these coastal zones are witnessing increasing economic activity resulting in loss or degradation of critical marine habitats, overfishing and pollution, and the associated impacts on ecosystem services. On top of this, the coasts are adversely impacted by floods, cyclones and severe storms. According to recent estimates by the Intergovernmental Panel on Climate Change, sea levels in India are expected to rise at the rate of 2.4 mm a year, and by 2050, the total increase may displace thousands of coastal people. This combination of natural and human forces and the uncertainties involved in their origins and impacts presents a major challenge to coastal people of India.

In this scenario, the challenges in managing such complex ecosystems are enormous and there appear to be no ready answers. Looking to the future, the strength that India has in marine biology and allied sciences will stand her in good stead to minimize these impacts. Another asset that India has is the high biodiversity in her seas (see p. 19) which is already being targeted by researchers for novel drugs and chemicals. The high diversity in fished taxa and the inherently high regenerative capacity of tropical fish stocks may also be helping in sustaining India's largely uncontrolled fisheries. Cross-learning from other developed and developing nations with similar situations and problems must be a way forward.

With advice from marine biologists, the Government of India has brought into force a number of laws for the conservation of marine species and habitats. Indian marine scientists continue to bring evidence from the latest research to formulate new policies to help mitigate human impacts and allow damaged ecosystems to recover.

Dr. K. Sunil Mohamed, Secretary of the Marine Biological Association of India

Front cover: A flock of flesh-footed shearwater (*Ardenna carneipes*) feeding on oil sardine in the southeast Arabian Sea. Image: R. Jeyabaskaran.
Back cover: Making a comeback? The spiny lobster (*Palinurus elephas*), needle rock, Lundy, southwest England. Image: Keith Hiscock.

Contents

Issue 5. October 2015

Image credits: Top: Asha de Vos.
Middle: Sanriku Volunteer Divers.
Bottom: Sunil Mohamed.

The common sawfish, *Pristis pristis*. Image: David Morgan.

Big, bizarre and seldom seen

Sawfishes are perhaps one of the most bizarre and fascinating of all marine animals. They can reach up to 7 metres in length, making them amongst the largest fish in the oceans; they can live in both marine and freshwater environments, and above all, their rostrum or 'saw' is a unique piece of biological engineering, which enables them to detect and hunt their prey. Yet sawfishes went unnoticed for decades. Last year, they were brought sharply into the conservation spotlight when the World Conservation Union (IUCN) highlighted that sawfishes were the most endangered of all sharks and rays. The IUCN's Global Sawfish Conservation Strategy also noted that, thanks to a lack of research on sawfishes, we have little idea of the areas they inhabit and what their conservation status is in each of those areas. Using the little information available, researchers believe that sawfishes may now be extinct in at least 20 of the 90 countries where they were thought to have been present in the past.

In the face of such solemn findings, however, researchers and conservationists have taken up the challenge. First, they must 'discover' where sawfish populations still exist, so that they can then do more in-depth research (how big is the population? Which species are present? What are the local threats?) and of course, develop conservation strategies that will be effective. In Africa, and Central and South America in particular, individuals, NGOs and researchers are collaborating in exciting new efforts to halt the decline of sawfishes. An article in the next edition of *The Marine Biologist* will document the race to find and protect the most endangered of all sharks and rays.

Ruth Leeney

The second Suez Canal

The Egyptian government officially opened the 'second' Suez Canal on 6th August 2015. It promises improved economic prospects for the country but the ecological effects, in particular invasive species, may be less desirable.

Recognising this momentous occasion, the Egyptian President reopened the fastest shipping route between Europe and Asia with a lavish ceremony and a national holiday. The £5.3 billion project deepened the main waterway and dredged another 22 mile channel parallel to it. This will effectively double the potential shipping traffic to an expected 97 ships a day by 2023 as well as allowing larger ships to navigate the route in both directions.

However, it seems little has been done to consider the ecological consequences with an environmental risk assessment lacking entirely. A group of 18 marine scientists published a warning in the academic journal *Biological Invasions* to challenge the Egyptian Government over the lack of sustainable management or mitigation for long-term ecological consequences.

Marine biologists cite invasive non-native species as the biggest threat to the region's marine environment. Spinefoot rabbitfish (*Siganus* sp.), the poisonous silver cheeked pufferfish (*Lagocephalus sceleratus*) and the swarming nomad jellyfish (*Rhopilema nomadica*) are just some of Red Sea species that have caused particular disruption in the Mediterranean in recent years. They have adversely affected commercial fishing and caused damage to underwater habitats, notably seagrass meadows, not to mention impacts on the wider marine ecosystem of the western Mediterranean (see Pancucci-Papadopoulou, M. A., 2013, Biological invasions and climate warming, *The Marine Biologist*, 1: 08).

Potential solutions include walls of air bubbles or highly salted sections to act as a barrier. The latter was in fact a natural property of the Bitter Lakes until they were diluted by expansion of the canal in 1956, and prior to completion of this latest phase of development, fluctuating salinity had limited introductions. Deepening of the canal is likely to open the door to deep-water species.

James Carlton, a specialist in marine bioinvasions with Williams College, Mystic, Connecticut, said "it is critical that the Suez Canal has an environmental impact statement, cooperation from canal authorities, and early detection and rapid response programmes to mitigate potential invasions."

There is evidence that such measures and a precautionary approach are needed to prevent further tropicalization of the Mediterranean. It is likely this body of evidence will grow as marine biologists study the impacts of the new canal in the coming decades.

Emily Miles

Aquatic Biodiversity and Ecosystems: Evolution, Interactions and Global Change. Liverpool, 30 August – 4 September 2015

Take 302 scientists, many of them leaders in their field, from more than 40 countries and put them in the excellent facilities provided by Liverpool University, and you have a mix that is bound to be informative and inspirational. The Aquatic Biodiversity and Ecosystems meeting provided a focus on evolution, interactions and long-term change – particularly how these shape patterns of biodiversity and the relationships between biodiversity and ecosystem functioning.

The Organising Committee, led by Louise Firth, ensured that the conference ran smoothly. The MBA provided support for the design of the conference website (www.aquaticbiodiversityandecosystems.org/) and prizes for best student oral presentations. The prizes were awarded to Rebecca Atkins (1st prize, University of Georgia) and Curtis Horne

Professor Steve Hawkins being presented with the collection of limpet shells from all over the world by conference organiser Dr Louise Firth.

(2nd prize, Imperial College London). Joint 3rd prize for was awarded to Ben Harvey (Aberystwyth University) and Carla Lourenco (Rhodes University).

The MBA's past Director, Steve Hawkins, was front-stage for much of the meeting which also marked his contribution to science and his declared retirement through the presentation of 'The Hawkins Collection' - 50 limpet shells from a range of aquatic habitats (freshwater, coastal and deep sea) donated by 63 aquatic scientists from all over the world. The collection provided a visual testament to Steve's impact on peoples' lives and careers over the past nearly 40 years.

Keith Hiscock

Bringing About a Sea Change

The ocean is vitally important and we all depend on the resources it provides. However, many European citizens do not understand how the seas and ocean impact their daily lives. In other words, European citizens lack a sense of 'Ocean Literacy' – an understanding of the ocean's influence on us and our influence on the ocean.

Sea Change, a new €3.5 million EU Horizon 2020-funded project, will address the challenge of raising European citizens' awareness of the intrinsic links between the ocean and human health. A consortium of 17 partners from 9 countries, plus an International Advisory Group, coordinated by the Marine Biological Association aims to foster responsible behaviour of citizens towards the seas and ocean and their resources. If Europe is to achieve sustainable exploitation of marine resources and maintain a healthy ocean we, its citizens, need to understand the extent of the medical, economic, social, political and environmental importance of the sea and how our behaviour can have an impact on marine ecosystems.

Over the next 3 years the consortium will develop a number of resources (animations, factsheets and e-books), deliver events, develop a robust network of marine educators through the European Marine Science Educators Association (EMSEA), examine marine governance and collaborate with transatlantic partners. Sea Change will work using both bottom-up and top-down approaches to engage with citizens and policy makers ensuring that efforts to sustain an ocean literate society in Europe will extend beyond the life of the project.

You can follow the progress of Sea Change online: www.seachange-project.eu, @seachange_eu and the Sea Change facebook page.

Fiona Crouch

Marine science in the UK's 'Top 20 REF Case Studies'

Anyone in academic institutions will know all about the recent Research Excellence Framework (REF), one aspect of which involved case studies of individual programmes of work. The UK Collaborative on Development Sciences (UKCDS)—a group of 14 UK government departments and research funders—have selected the 'Top 20 REF Case Studies' from across the UK to highlight the impact of UK research in international development.

Most of these 20 REF cases are concerned with terrestrial, medical and related issues, but there is one marine science issue amongst them. This is the one by Professor Charles Sheppard from Warwick University, regarding the Chagos marine research programme and the subsequent creation of that area as the world's largest no-take marine reserve. The research programme has introduced over 100 marine and island scientists to the archipelago from UK and overseas institutions. The work of all has established the area as being exceptional, with huge ecological and conservation value, and the work then became central to getting the archipelago declared as the world's largest no-take reserve. It is now considered to be a key (and increasingly rare) 'baseline' for scientists to understand what coral reef systems are like when they are not affected by direct human impacts such as fishing and pollution. As a result the Chagos marine reserve has become invaluable for a wide range of studies into tropical marine and island science.

www.ukcds.org.uk/the-global-impact-of-uk-research/conserving-marine-environments

Salomon Atoll in the Chagos Archipelago, British Indian Ocean Territory. Image: Anne Sheppard.

WWF's Living Blue Planet Report

According to the WWF's Living Planet Report, the human population is collectively mismanaging nature's resources. In September 2015, WWF released a special marine edition of the Living Planet Report which shows we are not treating our oceans any better.

Using the Living Planet Index (LPI), which is based on trends in 5,829 populations of 1,234 mammal, bird, reptile and fish species the report was able to compile a LPI for marine populations which showed a decline of 49 per cent between 1970 and 2012. The report also highlighted concerns over the global food supply, with global populations of the Scombridae family which includes tunas, mackerels and bonitos having fallen by 74 per cent. The report also states that although over-exploitation is a major problem, climate change is causing the oceans to change more rapidly than ever before. Reports from the UK look more positive as research shows 50 per cent of assessed stocks, including herring and haddock, are being fished sustainably. The full report can be accessed here: http://assets.wwf.org.uk/downloads/living_blue_planet_report_2015.pdf

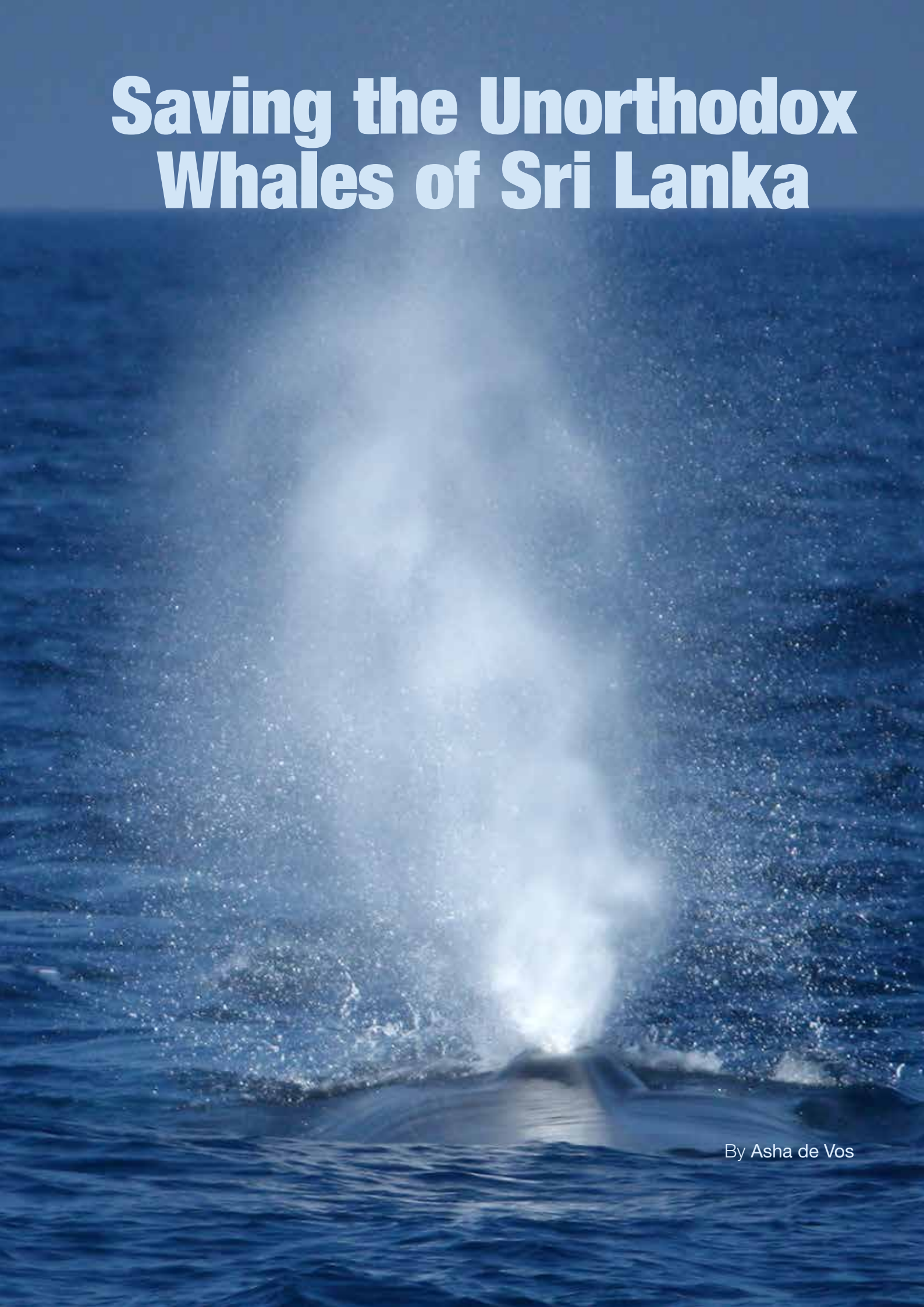
Harriet Yates-Smith

References and links for these stories can be found on *The Marine Biologist* website. Scan the QR code to view the web page.

For marine events, see the **UK Marine Science Events Calendar** at **www.mba.ac.uk**

For the latest news from the UK marine science community subscribe to the Marine Ripple Effect or follow on Twitter **@MarineRipple**

Saving the Unorthodox Whales of Sri Lanka



By Asha de Vos

While the width of its tail fluke is the length of a Sri Lankan fishing boat, it is with great respect that I manoeuvre through the blue whale's territory knowing that a mere flick could send me reeling. Nevertheless, it is with unending fascination that I stop to watch. Even as a scientist who has the privilege to spend many hours weaving through their world, each encounter reminds me how lucky I am to experience something that only the smallest percentage of our world has, and ever will get to marvel at.

The largest animal ever to roam the planet, the blue whale is fast becoming a national icon; a symbol for Sri Lanka. While Sri Lankans and visitors are free to roam and experience the entirety of the country, the blue whale is free to explore the entire ocean; however, those in our waters do not wander afar. The Northern Indian Ocean basin is home to a population of blue whales that, unlike others of this species, remain resident all year round. While the warm waters of the tropics are a key reason that people from around the world flock to our shores, it is precisely what prevents most whales in other ocean basins from hanging around throughout the year. Tropical waters are generally less food-rich than those in the cooler areas such as the poles. For a species that feeds exclusively on tiny shrimplike animals that are about half the size of a one-penny piece, and consume about two-thirds of the weight of an elephant in a single day, spending time in areas rich with food is key to their survival.

The realization that these whales were doing something different was what led me to pioneer the first ever research project on these, The Unorthodox Whales of the Northern Indian Ocean. Why unorthodox? They break the stereotypes that we had built for them; they do not undertake long-range migrations between cold feeding areas and warm breeding areas as many other populations do, they have a different acoustic dialect to other blue whale populations, they are actually the smallest of all blue whales reaching a maximum of just 80 feet (and thereby earning the title of pygmy blue whale) and they display different behaviours to their counterparts in other ocean basins. As a marine biologist who believes in research for conservation benefits, my earliest questions focused around a need to understand why a population of the largest animal on the planet would choose to remain in warm tropical waters year-round, particularly given that their feeding areas overlapped with some of the busiest shipping highways in the world. The shipping routes that run a mere 10 km off the southern coast of Sri Lanka are the main artery through the Indian Ocean and connect some of the biggest ports in the world – like Singapore and Dubai.

Because of their non-migratory nature, whale death by ship-strike, which is likely the biggest threat to whales the world over, is a 365-days of the year issue to this particular population. While my initial concerns were based on observations of near misses, it was not long before I had evidence of this threat – in the form of a blue whale that came in to the main harbour in Colombo wrapped on the bow of a container ship back in March 2012 (see image p. 8). It was immediately evident that this whale was a victim of ship-strike because the fresh carcass showed signs of internal haemorrhaging. As if to drive the point home, 12 days later we saw a carcass floating at sea showing signs of propeller gashes. While evidence like this is invaluable, it is rare, because often the carcasses will sink or get pushed offshore by prevailing currents. Knowing the importance of documenting this moment, I submitted a report on these incidents to the International Whaling Commission (IWC), the global intergovernmental body charged with the conservation of whales and the management of whaling. As a direct result of this report, the IWC reached out to the Sri Lankan Government highlighting ship-strike as a significant threat and identifying these whales as a population in urgent need of conservation action.

What is most important is the understanding that we are *all* to blame. After all, ninety per cent of all goods is shipped.


Image: Sopaka Karunasundara

While ship traffic has doubled globally since the 1990s, the Northern Indian Ocean has experienced a four-fold increase indicating the shifts in trade around the world, and highlighting that this threat is far from gone. However, as I began to delve deeper, I understood that it is also possibly one of the most tractable threats in our oceans. The resolution lies in identifying areas where blue whales and shipping lanes overlap, and then looking at options to try to reduce this overlap in a manner that is minimally negative for the shipping industry but positive for the whales. Together with a team of the world's most experienced scientists from the National Oceanic and Atmospheric Administration and the University of California, Santa Cruz, we are getting closer to making science-based recommendations to the Sri Lankan Government that can have the desired wins for everyone.

As I work in these waters in my single-engine 20-foot boat with a cloth canopy as my only luxury, and weave between container ships as if in a game of Frogger, I realize that any win for the whales is also a win for small boat operators who work and depend on these territorial waters, like the artisanal fishermen and whale-watch operators that buzz haphazardly around. These waters are dangerous not just to marine life, but also to those humans who are most dependent on them. Ultimately, every one of us is dependent on the environment for our health and wellbeing. It is time we realized that in order to survive we have to figure out how to live in harmony with nature.

On a personal note, I have learnt that the neat thing about pioneering research in a part of the world that has been devoid of it, is that suddenly everyone sees the path you have cleared and wants to work on the same issue. To me, this is victory, because it means that people are hearing, watching and caring, and together we can get closer to one of my life goals, that of reducing the risk of ship-strike to these giants.

Asha de Vos (whalessrilanka@gmail.com) is a Sri Lankan marine biologist and educator. She is the first Sri Lankan to obtain a PhD in a field related to marine mammal research and established the first long-term study on blue whales of the Northern Indian Ocean. She has published several key research publications on Sri Lankan blue whales, which have led to this population being designated as a species in urgent need of conservation research by the International Whaling Commission (IWC), and her pioneering work has been showcased widely in the international media. She is also a guest blogger for National Geographic. Asha is an invited member of the IUCN Species Survival Commission's Cetacean Specialist Group, a TED Senior Fellow, a Duke University Global Fellow in Marine Conservation and a Young Global Leader of the World Economic Forum. Images Asha de Vos except where otherwise credited. **ashadevos.com**

A new species of jellyfish from Southeast Asia

The discovery of new species of jellyfish or planktonic cnidarians is not a rare event even in recent years, as they are often found in the deep-sea or offshore waters where most of us, even scientists, are unable to access. However, it would be surprising if a large, conspicuous jellyfish, consumed by people was new to science. A new species of jellyfish that has been commercially harvested for more than 20 years for human consumption was discovered recently in central Java, Indonesia.

This new scyphozoan jellyfish, *Crambionella helmbiru*, belongs to the genus Crambionella, the family Catostylidae, and order Rhizostomeae. The specific name is derived from 'helm biru', meaning 'blue helmet' in Bahasa Indonesia, referring to the beautiful blue colour of its body and the nickname by which it is known to local fishermen 'ubur-ubur helm' (helmet jellyfish). Three species were formerly recognized in the genus, i.e. *C. annandalei C. orsini*, and *C. stuhlmanni*. Those *Crambionella* jellyfish are known to occur in the Arabian Sea, the Indian Ocean and the Red Sea. In 2002–2003, for example, mass occurrences of *C. orsini* were reported in the Gulf of Oman and the Persian Gulf, and large aggregations of dead jellyfish, thought to be this species, have been observed on the seafloor deposited within canyons and on the continental rise and are considered to contribute significantly to the annual downward flux of organic carbon in that area.

We originally found this species in Karang Duwur, Kebumen central Java, Indonesia in September 2008 during our investigations on jellyfish fisheries in Southeast Asia. We conducted further detailed research the following year to obtain sufficient specimens for study. Together with detailed measurements on morphology, we also applied molecular analysis to clarify the genetic differences with closely-related species, concluding that the harvested species was previously undescribed. The resulting paper was a unique mixture of the description of the species together with a description of the fisheries for the species Nishikawa *et al.* (2015).

Jellyfish have been used as food at least since 400 AD in China. According to FAO statistics, the amount of world production in jellyfish reached 30–50,000 metric tons in recent years: the values are higher than those for scallops or lobsters. In Southeast Asia, more than eight species of rhizostome jellyfish have been commercially harvested in Thailand, Indonesia, Malaysia, Vietnam and other countries. They are caught by various kinds of fishing gear including set-nets, drift-nets, hand-nets, scoop-nets, beach-seines, and hooks. These fisheries are characterized by large fluctuations in monthly or annual catch, and a short fishing season (typically a few months). Commercial jellyfish fisheries are generally small-scale and we have relatively limited knowledge about them, for example how and when the fishermen operate, how much is caught, and how the jellyfish are processed into commercial products for human food.

Discovery of this new species of commercially harvested jellyfish is considered important not only for its contribution to taxonomy, but also for the conservation of species diversity as well as the sustainability of fisheries targeting this species.

Edible jellyfish (*C. helmbiru*) are landed and transferred to the processing factory in Cilacap, central Java, Indonesia. Image: Nova Mujiono.

Jun Nishikawa
(jun_nishikawa@tokai-u.jp)

FURTHER READING

Kramp, P. L. (1961) Synopsis of the medusae of the world. *Journal of the Marine Biological Association of the United Kingdom*, **40**, 1-469.

Nishikawa, J., *et al*. (2015) A new species of the commercially harvested jellyfish *Crambionella* (Scyphozoa) from central Java, Indonesia with remarks on the fisheries. *Journal of the Marine Biological Association of the United Kingdom*, **95**(3): 471-481. DOI:10.1017/S002531541400157X.

Stiasny, G. (1921) Studien über Rhizostomeen mit besonderer Berücksichtigung der Fauna des malayischen Archipels nebst einer Revision des Systems. *Capita Zoologica, Deel*, **1**(2), Pp. 179, 150 figs. on 175 pls.

The origin of nervous systems

Pawel Burkhardt describes how marine organisms with ancient lineages are helping scientists to understand the evolution of nerve cells.

Marine organisms have long been important models in neurobiology, evolutionary biology and biomedical research, allowing many essential mechanisms of diverse biological phenomena to be revealed. Two very prominent examples are the Nobel Prize-winning work of Alan Hodgkin and Andrew Huxley uncovering the mechanism of membrane excitability using the giant squid *Loligo pealei*, and the Nobel Prize-winning work of Eric Kandel elucidating mechanisms of memory formation using the sea slug *Aplysia californica*. The ground-breaking work of Hodgkin and Huxley carried out at the Marine Biological Association (MBA) in Plymouth, was especially important as it revealed fundamental insights into how cells communicate with each other and how signals are sent along nerve cells. Their work provided the basis of our understanding of how we see, hear and feel things and how our brains work, and laid the foundations for other Nobel Prize-winning work including that of Erwin Neher and Bert Sakmann for their discoveries concerning the function of single ion channels in cells, and Roderick MacKinnon for structural and mechanistic studies of ion channels.

Nerve cells are the key building blocks of our nervous system and are central to information processing and transport in the brain. These specialized cells transmit information from one cell to the other via synapses, specialized contact sites that allow nerve cells to exchange information rapidly (Figure 1). Upon calcium influx, chemical signals called neurotransmitters (highlighted as green bubbles in Figure 1) are released from presynaptic synapses and diffuse across the synaptic cleft to react with receptors on postsynaptic synapses. This process involves a network of synaptic proteins that forms the molecular machinery underlying neurotransmitter release from presynapses and activation of neurotransmitter receptors on postsynapses (Figure 1). It is interesting to note, that while we now understand much of the underlying molecular mechanism of how nerve cells communicate, knowledge about how and when synapses and nerve cells originated is still in its infancy.

Understanding how nerve cells evolved is central to reconstructing how animals evolved such vast biological and behavioural diversity. When wondering about the origins of nerve cells we should not look at humans, fish or even worms. Many of the key synaptic proteins appeared long before animals, brains and nerve cells existed and can be found already in single-celled organisms, for example, in choanoflagellates. Let us first take a step back and look at what choanoflagellates are. Choanoflagellates are the closest known relatives of all animals (Figure 2A), making them a fascinating family of organisms for studying the origin and evolution of synaptic proteins. Choanoflagellates are a group of microbial eukaryotes (organisms whose cells contain a nucleus and other organelles enclosed within membranes) that live in many different aquatic (both marine and freshwater) environments. They are characterized by a single flagellum surrounded by a collar of actin-filled microvilli (Figure 2B). Choanoflagellates prey on bacteria; the undulation of the apical flagellum creates fluid currents that draw bacteria into the cells. Although all choanoflagellates have a single-celled phase in their life history,

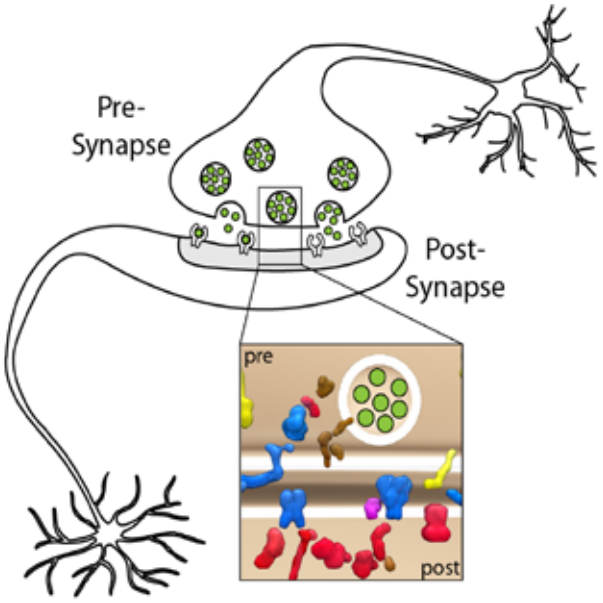


Fig. 1. Cartoon of two nerve cells with their most prominent feature: the synapse. Chemical signals called neurotransmitters (shown as green bubbles) are released from presynaptic synapses and diffuse across the synaptic cleft to react with receptors on postsynaptic synapses. Enlarged view: the network of synaptic proteins that forms the molecular machinery underlying neurotransmitter release. Cartoon modified from ClipArtHut.com.

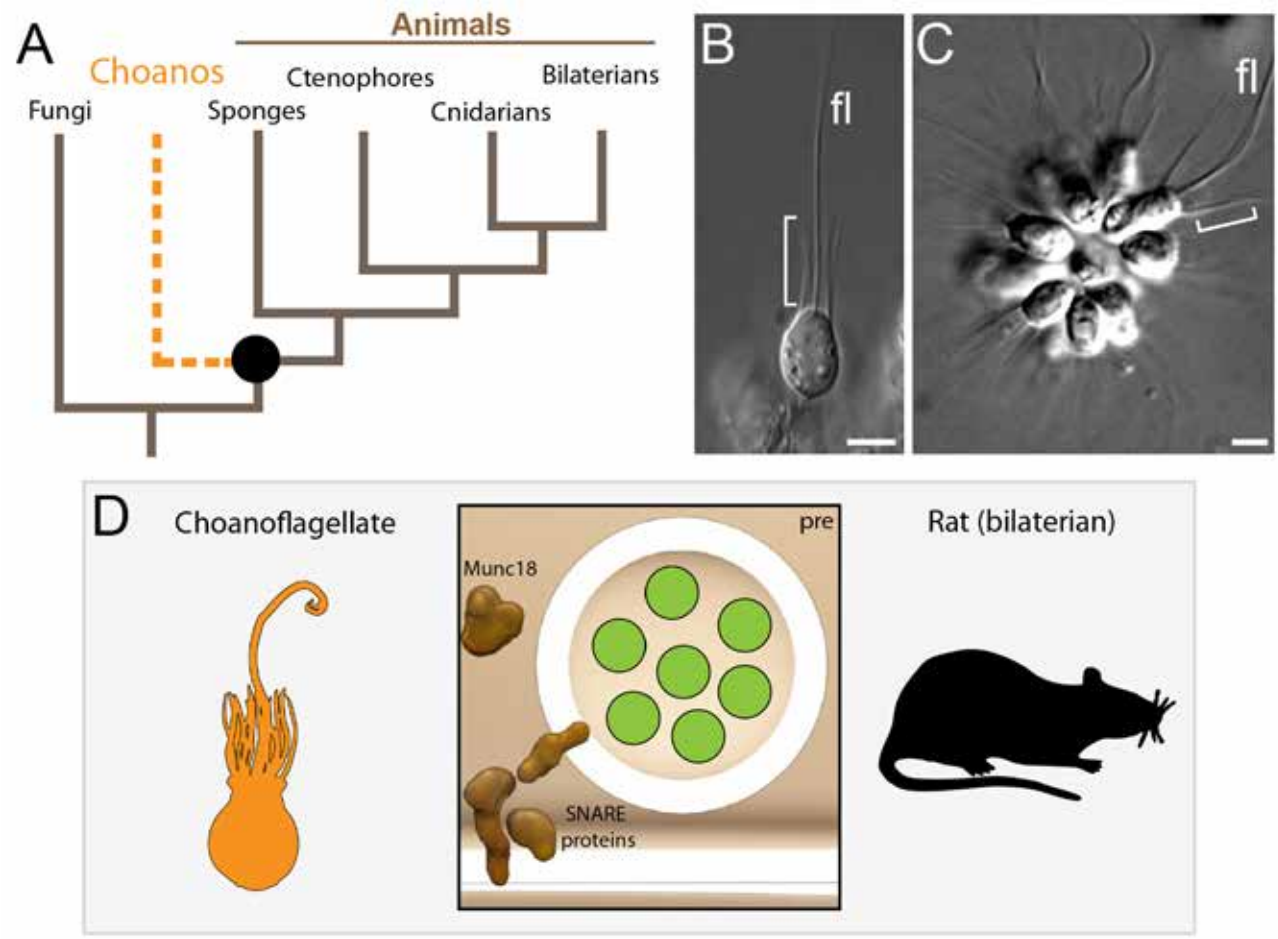


Fig. 2. (A) Choanoflagellates are the closest living relatives of animals. (B and C) Choanoflagellates have a single flagellum (fl) surrounded by a collar (bracket). They have a single-celled phase in their life history, but many species also form colonies. (D) The protein machinery for the secretion of neurotransmitters is conserved in choanoflagellates and rats. Choanoflagellate and rat illustrations were reused with modifications from phylopic.org. Scale bars: 2 µm.

many species also form colonies composed of multiple cells (Figure 2C). Most importantly, choanoflagellates do not have nerve cells, but the rich repertoire of neuronal protein homologues in choanoflagellates and the close relationship to animals make choanoflagellates ideal candidates to study the origin of synapses and nerve cells (Burkhardt *et al.*, 2014).

The release of neurotransmitters is mediated by a conserved set of proteins called SNARE and Munc18 proteins (Figure 2D). These proteins are found in every nerve cell and are essential so that nerve cells can talk to each other. We decided to look for them in choanoflagellates and to our great surprise, we not only found these proteins in choanoflagellates, but we were also able to show that the interaction between the two was the same as in nerve cells (Figure 2D) (Burkhardt *et al.*, 2011). Thus, an ancient protein machinery for the secretion of neurotransmitters was already present in the last common ancestor of choanoflagellates and animals. This machinery likely served as a starting point that helped to develop a more complex apparatus found in many animal cells, including nerve cells. This finding is intriguing on its own, but much more significant when combined with a growing body of evidence that many components of our nerve cells and brains evolved before the first animals appeared. For example, choanoflagellates express the same calcium channels as those used by nerve cells (Cai, 2008), have the same sodium channels that nerve cells use to send electrical signals along their length (Liebeskind *et al.*, 2011) and also have several proteins that nerve cells use to process signals from their neighbours (Alié & Manuel, 2010). Put together, these findings suggest that choanoflagellates have components for the three main functions of nerve cells: carrying electrical signals along their bodies; signalling to their neighbours with neurotransmitters; and receiving those signals (Marshall, 2011). It looks as though our nervous system was built up from several 'simple' systems and that these systems likely first evolved separately for different reasons.

Important questions still remain: How did the first nerve cells evolve? And did nerve cells originate more than once? To answer these questions we have to look at two of the most ancient animal lineages: the sponges and the ctenophores (Figure 3). Sponges have neither tissues nor organs, they are filter feeders which prey on bacteria as choanoflagellates do, and until very recently sponges were thought to be the most ancient animal lineage (Figure 3). This scenario fitted well

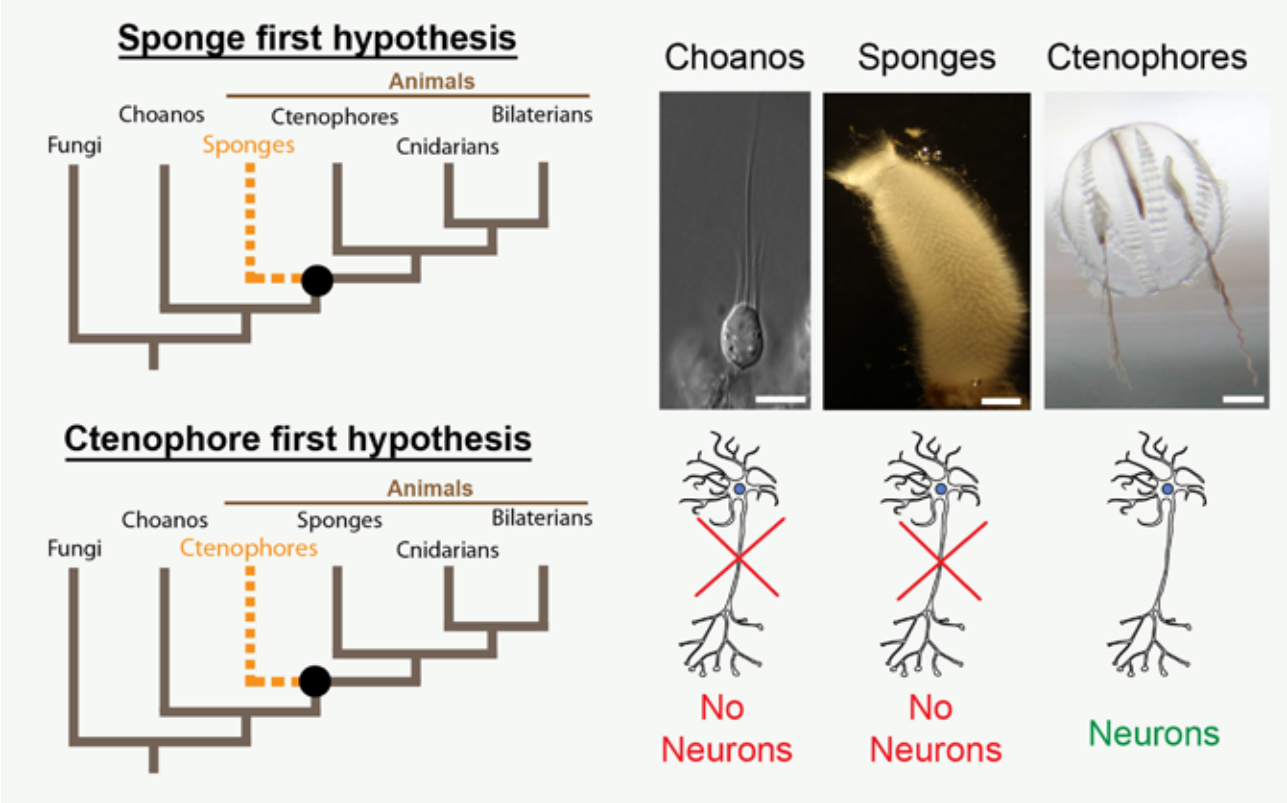


Fig. 3. Uncertainty at the base of the animal tree; sponges or ctenophores are currently considered to be the most ancient animal lineage. This has important implications for our understanding of the evolution of nerve cells, which are present in ctenophores, but absent in sponges. Either all nerve cells arose from a single ancestral cell or nerve cells originated independently in ctenophores and the rest of all animals. Shown are the choanoflagellate *Salpingoeca rosetta*, the sponge *Sycon ciliatum* and the ctenophore *Pleurobrachia pileus*, new model organisms which are cultured at the laboratory of the Marine Biological Association in Plymouth. Scale bars: choanoflagellates: 2 µm; sponges and ctenophores: 0.5 cm.

with observed morphological traits, as sponges lack synapses, nerve cells and a nervous system. Recent reports have now instead suggested ctenophores as the most ancient animal lineage (Moroz *et al.*, 2014; Ryan *et al.*, 2013,) (Figure 3) generating much excitement for evolutionary biologists and neuroscientists. Ctenophores, or comb jellies, are a group of carnivorous marine animals. If ctenophores are indeed the most ancient animal lineage, it has important implications for the evolution of nerve cells, which are present in ctenophores, but absent in sponges (Figure 3). One can think of two scenarios related to the evolution of nerve cells: either all nerve cells arose from a single ancestral cell; or nerve cells originated independently in ctenophores and the rest of all animals.

Through our experimental work at the MBA focusing on high quality basic research using choanoflagellates, sponges and ctenophores as new model organisms we will be able to elucidate the evolutionary history of synaptic proteins and understand the evolution of the first synapses and nerve cells. By reconstructing the origin of nerve cells, this research aims to provide new insights into animal development, health and disease.

Pawel Burkhardt (pawbur@mba.ac.uk) is a Research Fellow at the Marine Biological Association.

FURTHER READING

Alié, A. and Manuel, M. (2010). The backbone of the post-synaptic density originated in a unicellular ancestor of choanoflagellates and metazoans. *BMC Evolutionary Biology* 2010, 10:34

Burkhardt, P., Stegmann, C. M., Cooper, B., Kloepper, T. H., Imig, C., Varoqueaux, F., Wahl, M. C., and Fasshauer, D. (2011). Primordial neurosecretory apparatus identified in the choanoflagellate *Monosiga brevicollis*. *Proceedings of the National Academy of Sciences of the United States of America* **108**, 15264–15269.

Burkhardt, P., Grønborg, M., Mcdonald, K., Sulur, T., Wang, Q., and King, N. (2014). Evolutionary insights into premetazoan functions of the neuronal protein homer. *Molecular Biology and Evolution* **31**, 2342–2355.

Cai, X. (2008). Unicellular Ca^{2+} signaling "toolkit" at the origin of metazoa. *Molecular Biology and Evolution* **25**, 1357–61.

Liebeskind, B. J., Hillis, D. M., and Zakon, H. H. (2011). Evolution of sodium channels predates the origin of nervous systems in animals. *Proceedings of the National Academy of Sciences of the United States of America* **108**, 9154–9.

Marshall, M. (2011). Your brain chemistry existed before animals did. *New Scientist* **2828**, 11.

Moroz, L. L., Kocot, K. M., Citarella, M. R., Dosung, S., Norekian, T. P., Povolotskaya, I. S., Grigorenko, A. P., Dailey, C., Berezikov, E., Buckley, K. M., *et al.* (2014). The ctenophore genome and the evolutionary origins of neural systems. *Nature* **510**, 109–114.

Ryan, J. F., Pang, K., Schnitzler, C. E., Nguyen, A., Moreland, R. T., Simmons, D. K., Koch, B. J., Francis, W. R., Havlak, P., Comparative, N., *et al.* (2013). The genome of the ctenophore *Mnemiopsis leidyi* and its implications for cell type evolution. *Science* **342**, 1336–1344.

A blueprint for sustainable fisheries

Tom Pickerell describes Project Inshore, a collaborative venture between Seafish, the UK industry authority on seafood, the Shellfish Association of Great Britain, and the Marine Stewardship Council (MSC) to develop roadmaps for sustainable management of all English inshore fisheries.

Small, coastal fishing boats, or the 'Inshore Fleet', make up nearly three-quarters of England's fishing fleet. But relatively small landings per vessel, with varying market demand from one day to the next, make it hard to attract investment for scientific research and ultimately the data to inform decision-making.

While the small-scale inshore fisheries in England have been subject to a more coherent management regime for longer than the offshore fisheries (The Marine and Coastal Access Act 2009 modernized the way that inshore fisheries are managed in England and in April 2011, SFCs were replaced with Inshore Fisheries and Conservation Authorities (IFCAs)), it has been the offshore industrial-scale fisheries that have come to dominate the policy agenda as the Common Fisheries Policy has evolved over the last four decades.

Image: Seafish www.seafish.org

The offshore sector is the source of the larger part of commercial fish landings, but many more fishermen gain a living from inshore fisheries. Many more vessels, albeit smaller, are used in these fisheries, and arguably inshore fishing is much more closely integrated into the culture of coastal communities. Furthermore, an increasing proportion of overall landings comes from inshore waters – for example, in terms of overall value of English seafood landings, shellfish from inshore waters make a huge contribution.

The aim of Project Inshore was to utilize the MSC pre-assessment process strategically as a gap analysis framework to review the current status and management within English inshore fisheries. The MSC standard for sustainable fisheries provides a useful indicator of where a fishery is in relation to the FAO Code of Conduct for Responsible Fisheries. It also provides a structure to guide the development of future management action through bespoke fishery management plans for each IFCA. Ultimately, these plans will facilitate English inshore fisheries moving towards sustainability.

Sussex SFC piloted this approach in 2010 using the MSC pre-assessment framework to evaluate the performance of 26 local inshore fisheries. Subsequently Sussex IFCA adopted a 'programme of actions' to create a strategic direction for fisheries research based on the recommendations of the pilot. These included: establishing a limited normative catch, effort and biometric reporting system; developing appropriate stock assessment indicators; and developing appropriate biological reference levels for by-catch, discards, and habitat and ecosystem indicators.

Following the success of the pilot, we replicated this model with a nationwide pre-assessment of the inshore fisheries operating within the remaining English IFCA districts. The project was split into three stages: stage one mapped over 450 different fisheries within the English inshore sector (out to 6 nautical miles); stage two assessed all of the fisheries within each IFCA district using the MSC standard to score how each fishery was performing; and stage three produced roadmaps for sustainable management for each IFCA.

The stage two reports held few surprises for many species, and several species were considered ready to enter a full MSC assessment in their current state. Those fisheries highlighted as showing good practice include, for example, trammel net caught sole in the Western Channel, North Sea herring caught by drift net and Thames Estuary cockle.

Cod stocks in the North Sea – often perceived as a species to avoid –were found to be close to a level where they could meet the MSC Standard. The report showed that strong management measures had made a positive impact and concluded that once stocks reach the biomass limit reference point (Blim) all other areas of the fisheries were ready to enter a MSC full assessment. In June 2015, ICES produced their advice for North Sea cod and Blim had been exceeded; North Sea cod will enter MSC full assessment in the near future which is an incredible success story.

In total, around 50 fisheries were found to be performing at a level that could be considered in the short- to medium-term to move on to full MSC assessment. The remaining inshore fisheries require a longer-term programme of work to get them to perform at this level. Red gurnard, often a favourite among those encouraging consumers to choose alternative species, fared less well. A shortage of data about fish stocks and limited management of catches meant that there is an urgent case for investment to improve our understanding of this fishery. While a shortage of data does not mean that the fisheries are inherently unsustainable, that data will be increasingly important as the species gains in popularity and catches increase.

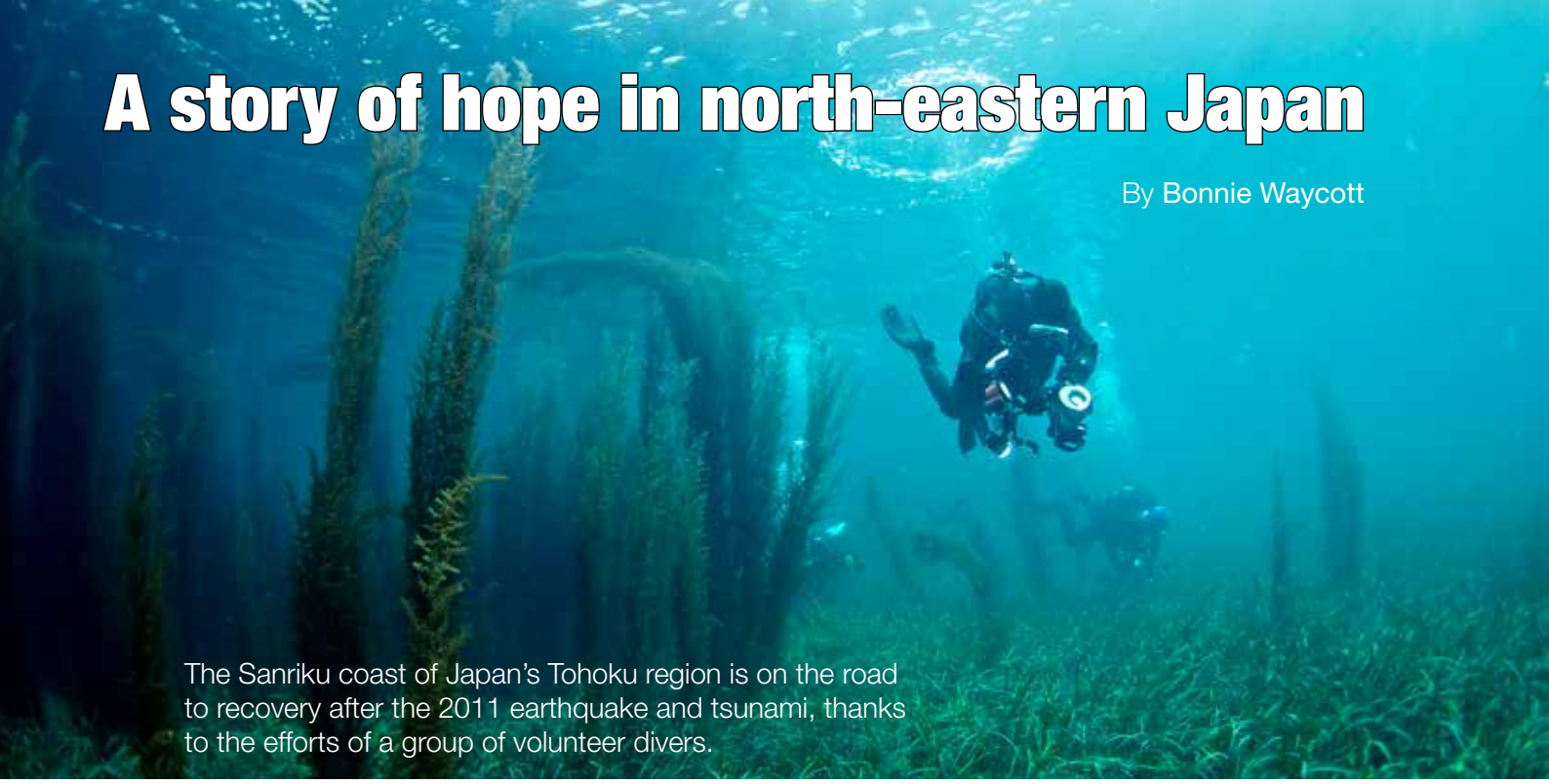
Stage three of Project Inshore was completed in April 2015 and the publication of roadmaps for sustainable management for each IFCA allow fishermen, managers, policy makers, NGOs and industry to work together in a focused and targeted way to deliver improvements across the country to ensure healthy English fisheries.

The Project Inshore approach is now being recognized internationally. Seafish has been contacted by organizations across the globe interested in applying the approach to their fisheries. We believe this model has potential for other bodies and countries to adopt as a blueprint for their own data-deficient fisheries management.

Tom Pickerell (Tom.Pickerell@seafish.co.uk)

A story of hope in north-eastern Japan

By Bonnie Waycott



The Sanriku coast of Japan's Tohoku region is on the road to recovery after the 2011 earthquake and tsunami, thanks to the efforts of a group of volunteer divers.

On 11 March 2011, a once-in-a-thousand-year earthquake and tsunami hit the Tohoku region of Japan. As the colossal waves washed over the area, Hiroshi Sato from Tohoku's Sanriku coast was working as a dive guide in Thailand. Upon hearing news of the disaster, he immediately set off on the journey home. Confusion and destruction had made the roads impassable, but on 15 March he finally arrived, and made his way to the places that were hardest hit.

Being a diver, Hiroshi was not only concerned about the destruction on land but also about the huge amount of debris that had been dragged into the ocean. About a month into the recovery efforts, a fisherman suggested to Hiroshi that as a diver, perhaps he might try pulling some of the debris out of the water. Many fishermen had lost boats, there was much wreckage to retrieve and perhaps sunken fishing gear could be salvaged. This led to a huge underwater clean up. As word spread, other divers from across Japan began joining in and Hiroshi established a group called Sanriku Volunteer Divers.

The Sanriku coast is characterized by steep hillsides plunging straight into the sea. The coastline is one of the world's major fishing grounds, and the bounties of the ocean have long supported the local people's lives, but the 11 March disaster changed everything. As farming structures had been badly damaged and much of the shore washed away, nobody could imagine how the underwater seascape might have changed, so in addition to retrieving debris, the volunteer divers were asked to investigate the area.

What greeted them was something unexpected: a lush growth of seaweed, healthy sea squirts and live abalone.

Two currents (*Oyashio* and *Kuroshio*) collide along the Sanriku coast, each rich in nutrients. The meeting of these currents also generates huge movements of seawater and creates an ideal environment for thick, strong seaweed known for its elasticity, and sea squirts that can grow in abundance thanks to large amounts of plankton. The earthquake also caused the Sanriku coastline to subside by about one metre, but this helped enlarge rich nursery grounds for fish and other species. One beach along the coast is a prime growing ground for eelgrass and 4 years on, the area of growth has doubled in size

as the subsidence of the sea bottom expanded the area in which the eelgrass can grow. As this environment is rich in nutrients, it is an excellent breeding ground for marine species including krill shrimp, brown algae (*Sargassum fulvellum*), small, non-commercial fish (sculpins, tubesnout and bitterlings), hermit crabs and the northern pygmy squid (*Idiosepius paradoxus*).

Today the volunteer divers are using any debris that has seaweed growing on it to create a physical structure that can provide food and shelter for marine communities such as abalone and scallop. Other work includes surveying the seabed and taking underwater photographs and footage. This information then undergoes expert analysis to assess future prospects for continued aquaculture and other fishing activities. Aqua-farming shelves for sea squirts have been built, and a joint collaboration has been established for salmon harvesting with a fishermen's cooperative that raises about 54 million salmon hatchlings each year and releases them into the water when they are fully grown. Hiroshi's work to remove debris from the river has allowed the salmon to return. Hiroshi himself has recently been introducing volunteer divers to the Salmon Swim. As the name suggests, divers can visit a nearby river and observe the salmon return and run upstream after 4 years' migration through the open ocean. The fish are now one of the area's highlights and a symbol of hope for the region.

This feeling of hope has now spread to the fishermen. Thanks to the volunteer divers, much information is available on the conditions underwater, and the increasing number of people coming to the area has allowed the fishermen to regularly share their experiences. For them, the ocean is their livelihood. The Sanriku coast depends largely on fisheries and related industries as the narrow flat lands and frequent cold summers only allow for limited agricultural production. As the coast is distant from transportation routes including major roads and the Shinkansen bullet train, it is hard for industries other than fisheries to develop. Because of this, fisheries along the Sanriku coast are huge local industries.

Local fishermen. Image: Bonnie Waycott.

Sanriku Volunteer Divers is now aiming to expand its efforts in other devastated areas with the cooperation of local fisheries unions and governments. Visits to primary and secondary schools are held to introduce the group's activities, while adults can find out more through talks in bigger cities such as Osaka and Tokyo. The people of Sanriku feel that instead of rebuilding their area to how it was before, they would like to create a new Sanriku, in which people have a chance to learn more about the affected areas through visits and volunteering.

As for Hiroshi, the 11 March disaster had a huge impact on his diving, something he began purely as a hobby. Now, diving is a way for him to restore the region he grew up in. Earlier this year, he also told me that although it is vital to continue spreading the word about the group's latest activities, what is even more important is to show gratitude by thanking those who have given up their time to volunteer.

Today, once again, he and his group of divers go underwater, continuing to salvage the remains of the Sanriku coast one piece at a time.

Bonnie Waycott Mem.MBA (bonniewaycott@gmail.com).

Images Sanriku Volunteer Divers except where otherwise credited.

Marine management?

Making an oxymoron more meaningful

Walls of large fish that have reached reproductive age can be seen commonly in tropical areas where controls on over-exploitation are effective. This is one such area on Ningaloo reef, Western Australia. Image: Anne Sheppard.

By Charles Sheppard

Consider this: a dynamite fisherman on coral reefs in some south-east Asian countries can earn double the salary of a university professor from that country. Now, whatever you may think about university professors, this does illustrate the ease by which a few members from the country's poorest sector can attain previously unimaginable wealth. The trouble is the activity leaves behind devastated and largely worthless areas of coral reefs that remain devoid of riches for several human generations. In other tropical countries, fishers use poisons, even DDT, to secure some protein from continually diminishing resources. In response to the obvious question of whether the DDT was harmful to those who ate the killed fish, the answer given was that, yes, of course, but not for several months perhaps, and he needed to feed his family that week.

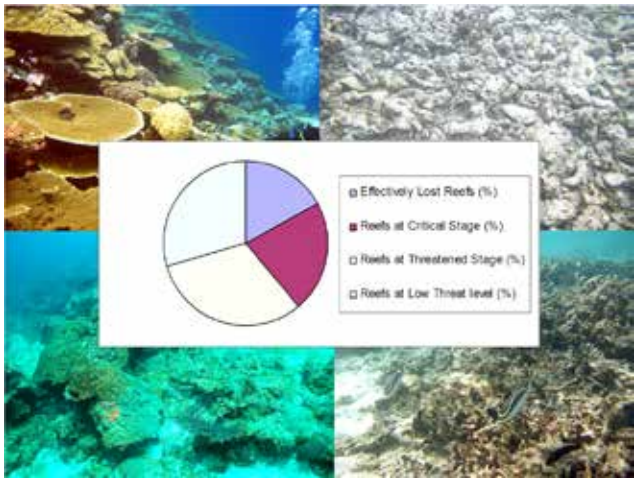
Now consider the regional level. Areas of shallow sea—where biological production is greatest—actually increase in value (in monetary terms at least) when turned into land, when landfill has made it real estate. Of our tropical shallow marine habitats, we are losing 1 to 2 per cent per year and to date we have lost about half of all the main habitats (Figure 1).

The simplest of maths should give cause for massive action, one would think, but it has not done so. Given the above examples and countless others, the reasons why the decline continues become more readily understandable.

A 'two worlds' model

The tropical marine world is, in one sense, two (at least) quite different worlds, which intersect on occasion but which at the present time scarcely seem to interact. One world is that of decision makers and of so-called 'managers', while the other is that of the poorest sector of society, where the majority of people make a living from their immediate environment. The lack of interaction can be illustrated by some simple, real examples. A golf course was built on fish spawning grounds; I have seen (but the golfers did not) the ruined fishing villages that had to be abandoned when the fish supply subsequently failed. It is not only golf, of course – any number of coastal developments can have similar effects. Shrimp ponds are carved out of mangrove forests but may last only a few years before having to be abandoned

Fig. 1. Proportions of reef in different states of health or damage, from very good, to completely destroyed. Photographs: examples of the four categories that the pie chart refers to.



for numerous reasons such as toxin or disease build-up. Some areas of Asia are scarred by thousands of hectares of lunar-like craters that are as sterile as the moon, where the felled mangrove stands once provided rich benefits. The idea of making protein is good of course, but shrimp is called the dollar crop because it is exported; the local people cannot afford it. The two worlds may intersect initially by providing labour for construction, but then they drift apart, one to urban flight because their land no longer supports them while the other world seems to float above those problems.

This sounds gloomy, and it is. Many initiatives bring rays of hope – projects that are locally beneficial to the poorest world, but yet the poorest still starve. You usually will not see them of course, but their famine continues.

Famine, why use that word? A look at Wikipedia lists many famines, all defined by a region and by dates when they started and ended, with the numbers of people who died. Today, the starvation going on in several tropical countries has no start or end dates, yet the number of people affected now far exceeds those in most of history's defined famines. Just one example: reports published show that over half of the mortality in under-fives in the poorest countries is due to malnutrition that makes fatal many of those diseases that you and I have likely suffered but fought off with little problem (Figure 2). Given the high birth rates in such countries, the term 'over half' means an awful number of children.

Remedies may exist, or could be made available, but dependency on protein from the shallow sea remains the main issue. This dependency is almost total for a huge number of people, with many more being partially dependent. Approximately three billion people live within 100 miles (160 km) of the sea, a number that could double in a decade as a result of human migration towards coastal zones.

Management, politics and economic drivers

The present systems and methods of marine habitat and fisheries 'management' are clearly failing in a global sense, and this is not sufficiently questioned.

We do not necessarily need more research. We generally already know enough underlying science to avert marine degradation with all its concomitant losses of ability to provide protein, support diversity, support shoreline stability and support people. The issue is more determined now by politics and economic drivers. Some say we can 'manage' the marine environment, but this is simply hubris, or conceit. We rarely successfully manage any one species let alone the 'sea' or its major systems. The best we can manage might be human impacts on the sea's potentially rich coastal habitats. Although that does not sound very appealing (stopping things is rarely popular) it is time to recognize that in many cases it is the only sort of management that has a chance of working.

Human laws *vs* natural laws

We must also align human laws with what we might call

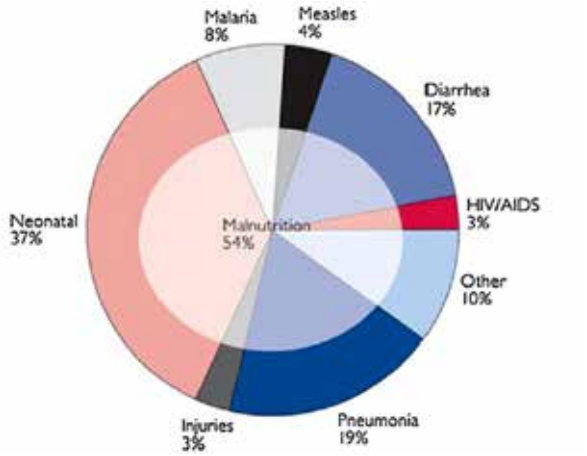


Fig. 2. Major causes of diseases in under-fives, showing the contribution of malnutrition (from Bryce *et al.*, 2005).

'natural laws'. One example from fishing (where data show that 'management' has been particularly poor): where regulations do exist they permit capture of large individuals and prohibit capture of undersized ones (Figure 3). But such regulations can severely exacerbate the problem because it is the older fish of many species that produce exponentially more eggs. If you want to keep up the supply of juveniles then, you need to retain sufficient 'big fat mamas'. Retention of those will allow people to live off the yield (the interest) tomorrow, instead of today's widespread practice of using up the breeding stock (the capital). Again, economics is the problem: it commonly suggests that the best way to profit is to catch them all now (someone else will if you do not), sell them, and invest the money into something else when it becomes necessary. This was concluded 50 years ago for whaling and we can see the same happening today with, for example, tuna fishing.

Giant marine reserves

But how do we let the big ones go to breed again next

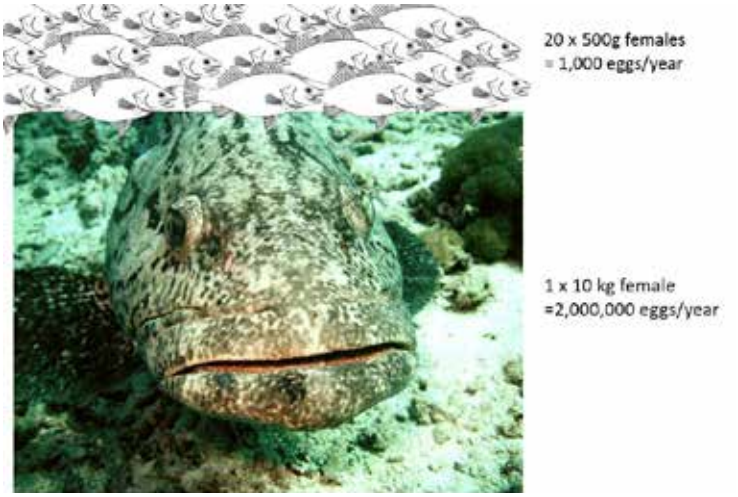


Fig. 3. Fisheries rules (where they exist) advocate keeping large fertile specimens and letting go the small ones. Which is best for maintaining a healthy population for tomorrow?

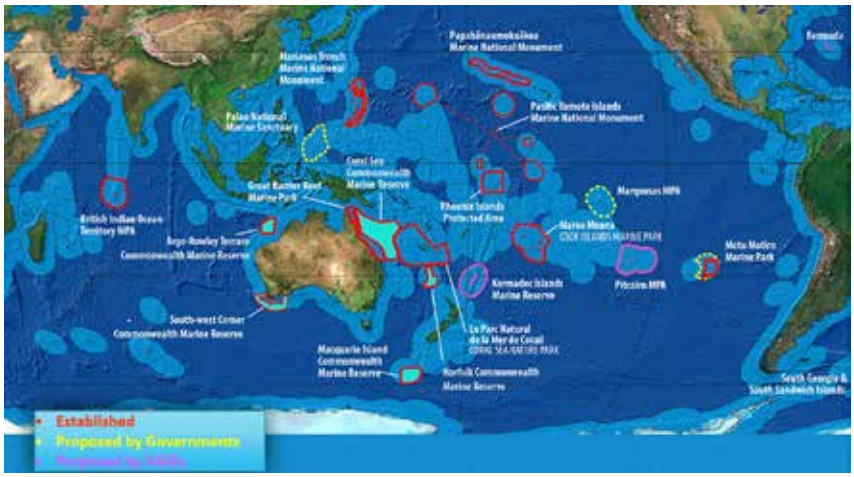


Fig. 4. Map of the emerging network of very large marine protected areas. Note that for tropical waters where pressures may be greatest, there is only one in the entire Indian Ocean, and none in the Caribbean, mostly due to intense environmental pressures.

year? There is only one way that I know of, and that is by strictly protecting large enough areas to make a difference. There is now a momentum for creating giant, strictly protected marine reserves and their number is increasing (Figure 4), although not without predictable and vigorous opposition from fisheries interests. Criteria for creation of large marine reserves must include: they are still rich enough to be worth protecting in the first place; they are large enough to make a regional or global difference; and they must have a governance that can enforce and sustain them. The number of places that fit these three criteria is distressingly few, but they are now an established form of marine conservation. These have made a huge impact on the amount of area protected.

Cynics have asked: "You suggest feeding more people by stopping them from fishing in huge areas?" The answer is yes, if done in a carefully planned way. In several Philippines' examples, strict protection of even modest sized reefs from fishing has resulted after just 3–4 years in several-fold increases in fish yield and incomes. Giant marine reserves scale this effect up.

Marine Spatial Planning (MSP) addresses many of the issues and conflicts arising around marine reserves. MSP is in its ascendence, and its need is urgent; you can only keep taking high production year after year if you do not eat into the capital (the big fat mamas). There is no way to do this other than by excluding fishing from significant areas. It takes only a small handful of fishermen, artisanal or otherwise, to deplete large areas of, for example, coral reefs, which is why 'management' that tries to integrate extraction with conservation so often has failed in tropical shallow habitats.

Opposition to marine reserves has often been depressing and generally ignorant. In other cases it may be far from ignorant but relies on the audience being ignorant, and those audiences may include the decision makers. Opposition to protected reserves is commonly abusive when the designation of a reserve threatens vested interests. Those supporting conservation efforts may be vilified, in personal terms also, when their science cannot be effectively faulted. Very dubious 'science' may be concocted to promote vested interests. (The poor people who depend on the ocean's produce have little voice in all this and cannot generally speak up for themselves. Quite simply they do not count.) Sometimes the vilification has been amusing, as when one lawyer called me a 'scientific fascist' for using data to demonstrate a point. Sometimes the abuse has been libellous too, but, hey, best to let it go – after all, copious informed feedback from colleagues invariably shows that the abuse backfired. The trouble is, the vested interests commonly do not give up – why would they when money is at stake? And law-makers in most places are generally inclined to believe arguments that are most convenient and immediately lucrative (although many educated officials are increasingly enlightened).

Despite all the opposition and the known limitations ('paper parks' and so on), marine reserves are here to stay. There is no substitute at present for maintaining diversity and productivity in tropical shallow seas. The way forward now is to improve their effectiveness, not to abolish them as some would have it. Otherwise we will continue to deplete our habitat by 1–2 per cent per year. We must recognize that this rate of decline is simply far too great to control through present ideas such as 'living in harmony with nature' or 'management' which are commonly promoted by those living in western comfort. We may one day manage to teach ourselves to do that, but as yet we have not – the numbers demonstrate it clearly. Marine reserves must become a key component of the world's marine systems where they can serve as reservoirs, and sources of food for the future, and reserves of biodiversity. Most may only be buying time, but time is what we need. If (let us hope soon) internationally organized MSP takes off, marine reserves will become a firm component of the global system. Only then might we fairly begin to start using the term 'marine management' in a meaningful way.

Charles Sheppard (Charles.Sheppard@warwick.ac.uk) is Professor Emeritus at the School of Life Sciences at the University of Warwick

FURTHER READING

Fenner, D. (2014). Fishing down the largest coral reef fish species. *Marine Pollution Bulletin* **84**: 9–16

Sale, P. F. *et al.* (2014). Transforming management of tropical coastal seas to cope with challenges of the 21st century. *Marine Pollution Bulletin* **85**: 8-23

Sheppard, C. R. C. (2014). Famines, food insecurity and coral reef 'Ponzi' fisheries. *Marine Pollution Bulletin* **84**: 1–4

Image: Ajin Madhav.

Indian seas – a megadiversity hotspot

By **N.R. Menon** and **N.G.K. Pillai** of The Marine Biological Association of India

Marine biological research in India dates back to the 18th century, and the surveys and expeditions conducted by Europeans, particularly the British. The most notable among these pioneers were great naturalists such as Francis Day (1829–1889), Nelson Annandale (1876–1924) and Herbert Robinson (1874–1929) who worked during the latter part of the 19th century and early 20th century. This foundation helped India to create a network of marine research laboratories in government funded institutions and universities all along the coastline. From the early days of taxonomic descriptions and records of marine fauna and flora, marine biological research in India has moved to advanced biology, physiology, biochemistry, microbiology, molecular biology and ecology of marine organisms.

India has a coastline of 8,129 km bounded by the Arabian Sea to the west and the Bay of Bengal to the east. The Indian Ocean lies south of its peninsula. With an exclusive economic zone spanning 2.02 million km2 and a continental shelf area of 0.53 million km2, the Indian marine environment harbours 15% of the global biodiversity. Of the 32 animal phyla, 15 are represented in India's marine ecosystem, with more than 15,000 species. The region has exceptionally high species richness, including over 3,000 species of fish, compared with around 1,200 in the next richest marine region, the western Atlantic, and around 500 species of reef building corals compared with about 50 species in the western Atlantic. India is one among the 12 mega-biodiversity countries with a wide range of coastal ecosystems such as estuaries, lagoons, mangroves, salt marshes, mud flats, rocky, sandy and muddy coasts, coral reefs, seaweeds, seagrass beds and more. They serve as nurseries for both fish and shellfish, many of which are commercially exploited. The Indian peninsula is bounded by 3 gulfs, the Gulf of Mannar on the east coast, and the Gulf of Kachchh and Gulf of Khambhat on the west coast. The east coast of India is endowed with the world's largest mangrove forest, the Gangetic Sunderbans. All three major reef types – fringing reef, barrier reef and atoll – are present in India. A network of 14 major, 44 medium and numerous minor rivers traverse through the country before they empty into the Arabian Sea and the Bay of Bengal. There are 17 lagoons (8 on the east coast and 9 on the west coast) along the Indian coast.

the Indian marine environment harbours 15% of the global biodiversity

Fishers engaged in a modern version of traditional boat seine fishing for small pelagic species. Image: R. Jeyabaskaran.

The oceanography of the Indian seas is

Box 1. The Central Marine Fisheries Research Institute (CMFRI) (www.cmfri.org.in) is the largest and one of the oldest (established 1947) marine laboratories in India. With its headquarters in Kochi on the south-west coast, it has nine research locations distributed on both coasts and employs more than 120 scientists. It has facilities to address research on marine taxonomy, biodiversity, environment, biotechnology and socio-economics, besides fisheries. The Marine Biological Association of India (MBAI) owes its origin to erstwhile researchers of the CMFRI and is currently housed within its campus.

influenced by the two tropical monsoons, the south-west and north-east and this shapes the physical features of the east and west coast of India. The west coast is characterized by heavy surf and rocky shores, islands formed of oceanic atolls, intense upwelling, mud banks and high primary productivity. The ephemeral mud banks of Kerala (along the south-west coast) are a unique phenomenon appearing during the south-west monsoon. Fishermen come from far and wide to harvest tonnes of fish from traditional canoes. The east coast on the other hand has extensive beaches, lagoons, deltas and marshes, islands of mainly continental and volcanic origin, weak upwelling during the north-east monsoon and lower primary, secondary and fish production than the Arabian Sea.

Microorganisms represent the largest reservoir of biodiversity in India and research on marine microbes is booming. Microbes of the seas including fungi and bacteria in coastal, offshore and deep sea waters are being targeted by researchers. Among the microalgae that contribute to the primary production in the Indian seas, diatoms make up 52 per cent, followed by dinoflagellates. Altogether over 800 species of phytoplankters have been recorded from the Indian seas. A total of 844 species of seaweeds distributed among 217 genera are known from Indian seas. Seagrasses form an integral part of many ecosystems and so far 14 species have been recorded. The Indian mangroves cover about 4,827 km2 and a total of 39 mangrove species are known from India.

Studies on the sponges of the Indian Ocean started in 1765. So far 486 species of marine sponges are known to occur in Indian seas. Coral reefs are found in the Palk Bay, Gulf of Mannar, Gulf of Kachchh, central west-coast of India, Lakshadweep and around the Andaman and Nicobar islands. A total of 50 genera and 13 sub-genera of reef-building corals are known to occur in Indian reefs. Many of the lower marine invertebrates are targets of research for development of drugs and molecules useful to man.

A wide diversity of crustaceans (2,934 species), molluscs (3,370 species), echinoderms (765 species), cephalochordates (6 species), ascidians (47 species), thaliaceans (48 species), fish (2,456 species), sea snakes (26 species), sea turtles (5 species) and marine mammals (25 species) are reported from Indian waters.

The marine fisheries sector plays a vital role in the Indian economy. It addresses food and nutritional security, employment and livelihood support. Its exports are worth more than US$ 5 billion annually. The sector provides employment and income to over three million fishers. The annual marine fish production recorded tremendous growth during the post-independence era from 0.6 million tonnes in 1950 to 3.94 million tonnes during 2012. Fishery resources are made up of a large number of coexisting species, making the fisheries multi-species and multi-gear with inherent complexities in management. Several sea farming technologies have been developed for farming shrimps, lobsters, oysters, mussels, clams, seaweeds, sea cucumbers, finfish and for the production of marine pearls. While shellfish are now being farmed extensively along the coastal areas, other technologies await adoption and commercialization. Much of the work on fisheries has been carried out at the Central Marine Fisheries Research Institute (see Box 1.).

Habitat loss, uncontrolled developmental activities in the coastal zone, climate change impacts, over-exploitation of resources, coastal pollution, haphazard beach fortification, sand mining and drilling operations are among the threats to marine life of the Indian seas. With advice from marine biologists, the Government of India has brought into force a number of laws (the Biological Diversity Act, 2002, the Indian Wildlife Protection Act 1972, and the Marine Fisheries Regulation Acts of Indian maritime states are examples) for the conservation of marine organisms and their habitats.

N.R. Menon and N.G.K. Pillai are Vice Presidents of The Marine Biological Association of India (www.mbai.org.in).

Dreaming of a digital ocean ...

The Earth, the Blue planet, is so called because its largest biotope is a vast and deep intertwined blue expanse of salted oceans and seas. This liquid is filled with trillions of living organisms that are mostly invisible to the naked eye. These life forms have allowed us to breathe and to conquer terrestrial habitats. They are our ancestors, the rocks we use to build our homes, the oils we use to fuel our society, the food we eat (or the food of our food), and they may also hold the key to a healthy future for our planet in these troubling times of climate change.

Many theories have been proposed, discussed, discarded, and buried about the origin of life; often the ocean is a component of the mysterious mix that gave rise to the chance for life on our planet. Cells first appeared, close to deep sea volcanoes, or perhaps it was in rock pools; in shallow bays, stromatolites trapped sedimentary grains that mark the origin of biological deposits—to which we owe much of the geological nature of the continents—and their cyanobacteria established photosynthesis that made their own food source and released precious oxygen. Life expanded and thrived in these early oceans but there was no one to record the creatures that inhabited them. Nowadays, only the bones and stones left behind provide us a glimpse of the identity of those sea creatures and narrow insights into how they lived. For many millions of years there were no eyes to see them, and no arm and digits to draw them or to build cameras to record this massive world which is up to 12 km deep and which spans 71per cent of our Earth.

Naming and picturing the world around us is the oldest scientific endeavour of mankind. The first witnesses of ocean life drew dolphins on rock faces with bright natural pigments. These are the first known images of an ocean creature painted by men, probably 10,000 years ago, a beautiful first attempt to approach the Great Blue Beyond. Since then, generations of scientists like Aristotle, Guillaume Rondelet and Antoine van Leeuwenhoek opened our eyes through the first microscopes to the magic wonders of the sea, the tiny 'Animalcules', the ever-wandering drifters. Since then the list has been ever growing of those who have made images of ocean life: painting jellyfish (François Péron), engraving radiolarians (Ernst Haeckel), drawing the magical vampire squid (Carl Chun), and in our time recording live animals underwater (Jean Painlevé).

Technological development allows us today to digitally image much smaller organisms (viruses and giruses) collected from the Mariana Trench, the deepest part of the oceans. Cameras provided us with colour imaging and the possibility to create digital recordings of those organisms. Rather than physically capturing an ever-growing number of ocean drifters and other deep-sea creatures during increasing numbers of marine expeditions, we believe that we can take advantage of the digital age to create an interactive 'Deep Blue'. Not the IBM brain simulation project, but a Digital Ocean. Using advanced technologies for imaging and visualization we could digitally follow the ocean currents, observe fish in their full three dimensions, and swim within coral reefs that are being kept safe from unwanted human exposure and

Fig. 3. Portrait of a recently hatched green turtle, *Chelonia mydas*. This species is considered highly endangered. Location: Saint Brandon (Cargados Carajos), Mauritius, Indian Ocean. Image: Aldine Amiel/TARA Oceans/Kahi Kai Images.

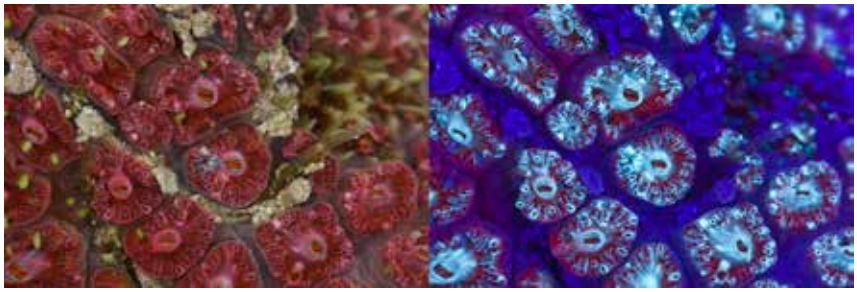


Fig 1. Recording coral fluorescence. An ongoing project involving three dimensional and multispectral analysis of coral communities from reef to symbiont developed in the author's laboratory. Image: Luis Gutierrez-Heredia.

Fig. 2. E. Reynaud on board Tara off Spain after two-and-a-half years sailing around the world. Image: Julien Girardot.

impacts (Figure 1). We could at the touch of a screen receive physical and chemical data registered by an army of sensors and buoys floating worldwide. No need for massive ships thirsty for fuel and other black smokers that grid the ocean daily. Yes, we have a dream, the dream of a Digital Ocean.

But first we have to recognize our own part in this. We sailed on smoking ships; we harvested and killed millions of drifters. We still do, but we wish to set our dream free, and for the past few years we have been trying to work differently. We work with local populations who will directly benefit from a Digital Ocean and need it not just to survive, but to thrive, and we work with non-destructive technologies enabling us to record high quality 3D images of animals, whatever their size, along with their environmental parameters. We foresee communities that are able to gather the data they need, not the data we want, and are able to make sense of the results for their own benefit. Yes, we have a dream, the dream of a Digital Ocean.

Tara Oceans (with *Kahi Kai***)**

We took part in the Tara Oceans Expedition (2009–2012), a unique circumnavigation of the Earth's oceans. Tara is a 35-metre schooner designed to analyse and collect plankton communities as well as coral specimens, to establish a freely available database comprising satellite images, geochemical data, images and genomic sequences, in an attempt to holistically describe these organisms. We designed and maintained The TAra Oceans Marine biology Imaging platform (TA.O.M.I) (Figure 2). This unique expedition was challenging due to the Tara's small size, relative lack of stability and the limited amount of available energy to power the optical instruments. Nonetheless, all the effort put into this project was worthwhile. It was a major success and during the journey we collected hundreds of thousands of images. The results gathered during the Tara Oceans expedition led to many scientific publications. The database to underpin the Digital Ocean is in the process of being assembled sample by sample and laboratory by laboratory. We also shared our experiences and techniques through the publication of a book *Imaging Marine Life: Macrophotography and Microscopy Approaches for Marine Biology* (Reynaud E.G. (ed.), 2013), to help marine researchers worldwide to image their favourite creatures.

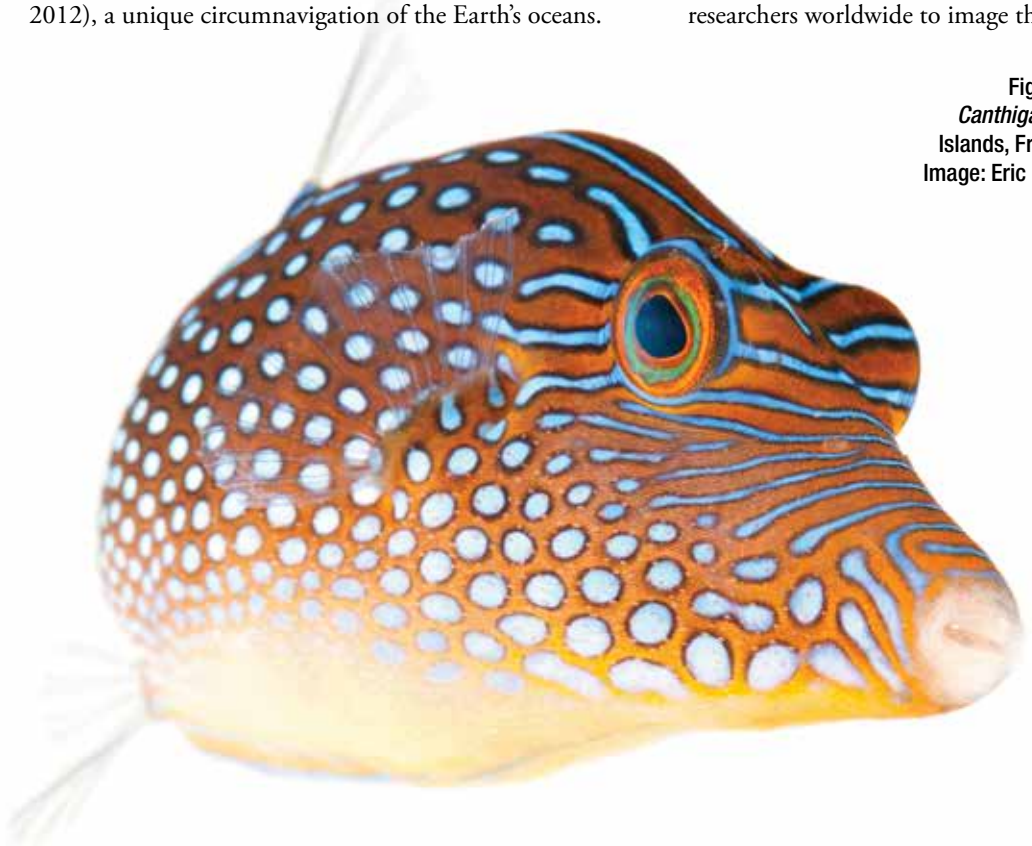


Fig 4. Portrait of the Papuan toby, *Canthigaster papua*. Location: Gambier Islands, French Polynesia. Pacific Ocean. Image: Eric Röttinger / TARA Oceans / Kahi Kai Images.

Kahi Kai **(www.kahikai.org)**

Kahi Kai means 'unique ocean' in Hawaiian and is our French–Hawaiian non-profit organization that aims to make marine science accessible to the general public and students. Our mission is to highlight the connections that exist between all the seas and oceans of the planet and to raise awareness of the fragility of the marine world we all depend on. We develop scientific tools and have launched a project to portray the amazing biodiversity of marine sea creatures around the globe. We imaged more than 1,000 different species alive, giving us the chance to admire their colourful patterns and intriguing behaviour, and released them immediately after the photo session back into their natural habitat (Figures 3 (p. 21) and 4). The images we take are used to illustrate scientific articles, journals and magazines as well as to organize interactive exhibitions around the world. We strive to raise awareness of our shared responsibility to conserve our oceans by introducing the public to the fascinating and diverse organisms found therein. Educating our youngest generation will have the greatest impact as children have a dual role as current consumers and future policy makers. By providing them with a basic understanding and respect for the ocean, and fostering a passion and interest in marine science, we hope to ensure that our future leaders will be capable of making informed decisions regarding ocean conservation.

A new challenge: *Va'a Motu*

Our latest endeavour is ongoing in Fakarava, an atoll

Fig. 5. Kite aerial survey of the northern pass of the Fakarava Atoll using an Ultrafoil 15. Image: Julien Girardot.

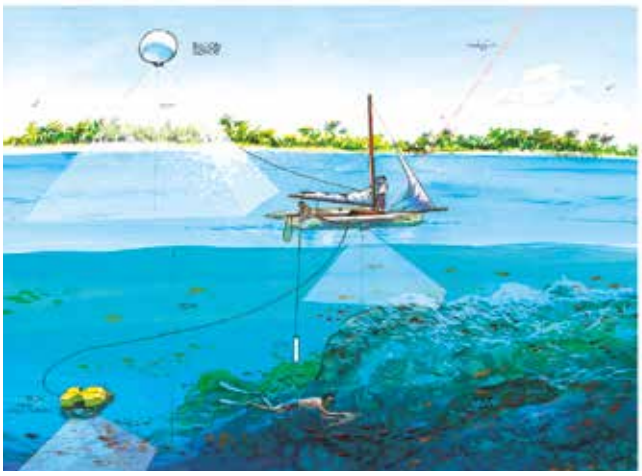


Fig. 6. The Sur *va'a motu*. An artist impression of the scientific part of the project Image: Benjamin Flao.

in the Tuamotu Archipelago of French Polynesia and a UNESCO Biosphere site. There, we helped bring back to life traditional Polynesian sailing canoes named *Va'a Motu*. In close interaction with the local non-governmental organization, we are developing marine surveying systems that can be used on a small *Va'a*. We are combining aerial kite photography (infrared and colour) with small omni-directional underwater cameras and open-source software to create a digital map of the lagoon and its inhabitants (Figures 5 and 6). We use wind and solar energies for our devices (including recharging batteries) to be as carbon-free as possible. We plan to create a complete digital recording of the Fakarava marine life and step closer to our vision while striving to reach carbon neutrality. These tools, specifically designed for the *Va'a*, will become the property of the local community allowing them to regularly map and survey parts of the atoll they wish to follow or zones that maybe used in the future for large developments (e.g. new piers for cruise ships). This citizen science led by the local community and supported by a scientific team is part of our dream, the dream of a Digital Ocean.

Swim long and image well!

Eric Röttinger[1], Aldine R. Amiel[1], Noan Le Bescot[2], Luis Gutierrez-Heredia[3], Peter Flood[3] and Emmanuel G. Reynaud[3§]

1. Institute for Research on Cancer and Aging, Université de Nice-Sophia-Antipolis, CNRS UMR7283, INSERM U1081, France

2. Station Biologique de Roscoff (CNRS), Roscoff, France

3. School of Biology and Environmental Science, University College Dublin, Ireland

§ Correspondence should be addressed to: Dr Emmanuel G. Reynaud (emmanuel.reynaud@ucd.ie) Room 141, Science Center West, School of Biology and Environmental Science, UCD Science Centre West, University College Dublin, Belfield, Dublin 4, Ireland.

Ten years in the making: a comprehensive guide to the marine zooplankton of southern Britain

Actinotroch larva of the phoronid *Actinotrocha branchiata.*

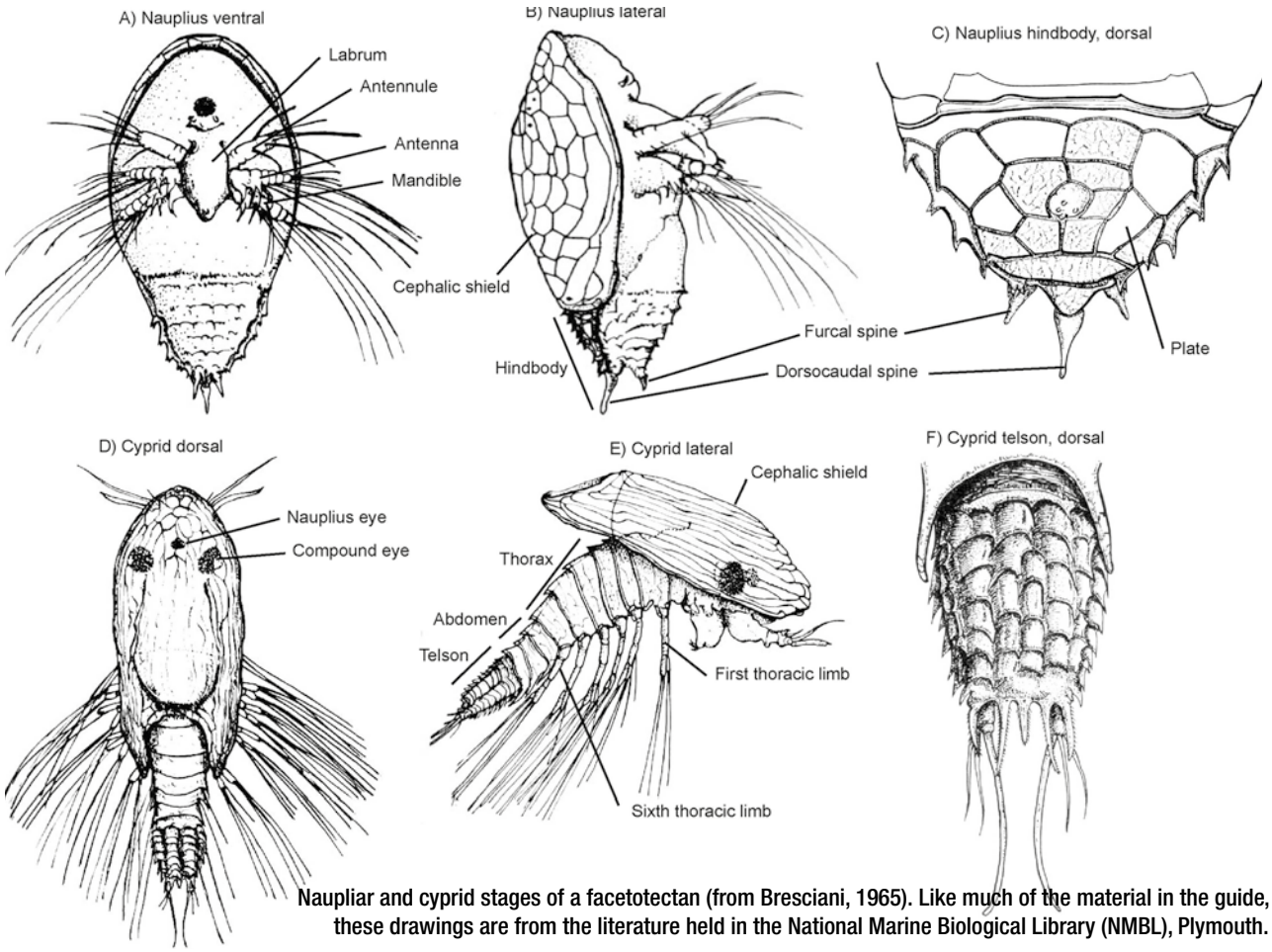
Dr Dave Conway has spent a lifetime studying zooplankton and over the last ten years has been bringing together identification information from hundreds of original sources into a single resource for anyone with an interest in the zooplankton of north European seas. **Kelvin Boot** spoke to him to find out what lay behind the compilation of the guide to marine zooplankton of southern Britain.

KB: What was the catalyst for compiling the guide?

DC: The zooplankton of the northern European seas has probably been studied more than that of any other region in the world, and whilst there are some basic zooplankton guides available for this area, they are mainly for students and cannot be used for accurate species level identification. So, there was no single, comprehensive, taxonomic guide to the range of species and larval stages found, available to researchers. Taxonomic information was out there, but it was spread through a wide range of monographs, scientific papers and some group identification guides. If you are a researcher working across a broad spectrum of species, unearthing that literature was very difficult, unless you had access to excellent library facilities, because much of this material is very old or out of print.

KB: And Plymouth has such a library?

DC: Yes, the National Marine Biological Library has grown since the very beginning of the Marine Biological Association (MBA) and amongst its nearly 15,000 books,



Naupliar and cyprid stages of a facetotectan (from Bresciani, 1965). Like much of the material in the guide, these drawings are from the literature held in the National Marine Biological Library (NMBL), Plymouth.

80,000 reprints and almost 5,000 serial titles, there is a huge amount of information about plankton. Plymouth, in south-west Britain, is also ideally located for plankton studies, with currents bringing oceanic zooplankton into the English Channel, so the range of species sampled actually covers the majority found over the shallower parts of the northern European continental shelf with the exception of the Mediterranean. Plymouth is also one of very few centres in northern Europe where comprehensive long-term data on the local marine zooplankton and marine fauna in general, are available, and continue to be collected by the MBA and the Plymouth Marine Laboratory.

KB: Compiling the guide must have been something of a labour of love?

DC: Yes, I have been studying plankton for more than five decades and worked on this guide over the last ten years as time allowed, so it is the result of many, many months of searching out the sources, correlating and comparing the information, updating the taxonomy, then bringing it all together in a form that can be used. I am the compiler who has drawn together the results of painstaking research carried out by an army of plankton researchers over the last 100 years or more. Without them I could not have begun, let alone finished the task, and I would also acknowledge the MBA for encouraging me to bring the information together as a contribution to the Natural Environment Research Council 2025 Strategic Research Programme.

The guide to the marine zooplankton of southern Britain is in three parts, all freely available online.

KB: Who is the guide for?

DC: The idea when I first started was as an identification resource just for Plymouth researchers and students working on English Channel zooplankton, but I decided to extend it to include species that have been found in adjacent waters. The result is a comprehensive guide to almost all the north European shelf

species that is useful to any researcher, or indeed anyone with an interest in zooplankton.

KB: The result is impressive, three volumes and 572 pages.

DC: Yes, it is now pretty comprehensive as a guide to our zooplankton. The commonest truly planktonic species and the most widely studied groups are covered in most detail, but some information is also included on benthic, epibenthic and parasitic species that are sampled occasionally. For all groups there is at least information on their morphology, guidance on their identification and, most importantly, bibliographies giving other identification resources, which were consulted during compiling the guide. Rather than wait for everything to be completed, we decided to publish the guide in three parts to make the information available as quickly as possible.

KB: And all of this is free to download?

DC: Absolutely. There has never been a more crucial time to study plankton, as the ocean and its inhabitants face the challenges posed by climate change, ocean acidification, microplastics and multiple other stressors. Zooplankton are amongst the first organisms to be affected by even small changes, so providing early indications that things might be going wrong or spotting changes in distributions relies on accurate identification. These guides provide a 'one-stop-shop' for plankton identification in north European seas. I hope they make life easier for those already working on plankton and encourage the next generation to delve into this usually hidden, but always fascinating world.

The guide is available on the Plymouth Marine Science Electronic Archive (PlyMSEA). Reference: The marine zooplankton of southern Britain, Dr Dave Conway, edited by Anthony W G John.
http://plymsea.ac.uk/id/eprint/5631
http://plymsea.ac.uk/id/eprint/5633
http://plymsea.ac.uk/id/eprint/6360

A new app for unfamiliar seafood

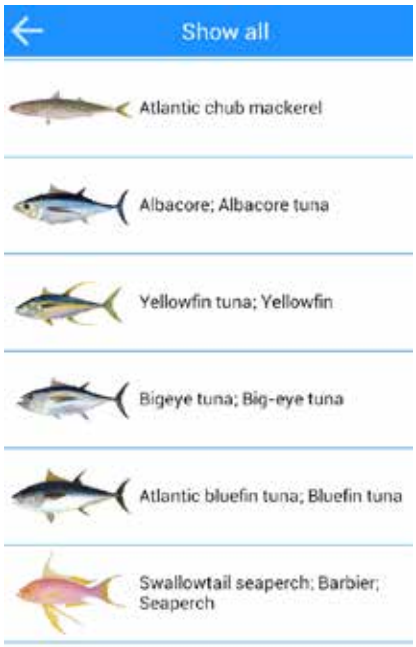
A new app helps tourists learn about the seafood of Madeira. By Margarida Hermida.

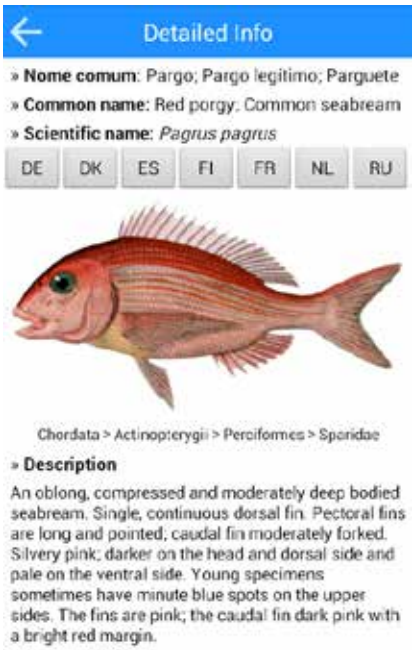
Madeira is well known for its natural heritage, picturesque views, and subtropical seas which are popular with a great number of travellers who are interested in the marine environment. More than 500 fish species occur in its waters, attracting marine mammals as well as human consumers. Black scabbardfish, limpets, and salt dried skipjack tuna are some of the local delicacies. Yet it is often hard to know what is on the menu, as most species on offer are unfamiliar to tourists. In this context, a mobile application was developed to provide consumers with relevant information on local fish and seafood.

The app was developed by the author, a biologist, and Carlos Lucas, an IT engineer, and resulted from collaboration between the Regional Fisheries Directorate and CIIMAR-Madeira, co-promotors of the Oceanic Observatory of Madeira. It is available in English and Portuguese and includes the scientific name and common names in several additional languages.

Each species has a file including a short description, biology and habitat, distribution, size, seasonality, and conservation status. A nutritional composition table is provided whenever that information is available in the scientific literature. Additional information of interest to consumers includes the traditional gastronomic uses and fishing methods.

This app constitutes an opportunity to communicate scientific knowledge to the public while providing a useful service to fish consumers. Starting with information that will appeal to a wide range of users, such as nutritional composition and gastronomy, this app can encourage learning about less common species, and about aspects of the biology, ecology, and conservation of a variety of marine fish and invertebrates. The app is available on GooglePlay and on the AppStore:
bit.ly/MadeiraFish-Android
bit.ly/MadeiraFish-iOS





Margarida Hermida
(margaridahermida@gmail.com)

New guidance for offshore renewable energy installations

By Shaun Nicholson, Greg Tomlinson and Ross Hodson.

The first offshore wind turbines commissioned in the UK were installed at Blyth, Northumberland in late 2000. Since the construction of the two-turbine Blyth project the offshore wind energy programme has undergone significant scaling-up and the UK is now the world leader, with over 5GW of operational installed capacity (June 2015) and a large number of major projects comprising wind farms either consented or in planning. Whilst the wind energy sector is now well-developed, there has been increased effort to accelerate the pace of installation for both wave and tidal energy generating devices. Despite the substantial growth in the renewable energy sector there remain a number of uncertainties, and lack of guidance is considered a key barrier to development of renewable energy projects.

The Marine Management Organization (MMO) is a non-departmental public body responsible for the licensing, planning and enforcement of many activities in the seas around England, and (presently) certain projects within Wales's inshore marine area. The MMO issues Marine Licences for renewable energy projects up to 100MW capacity in the English marine area, and is responsible for granting section 36 consent for offshore electricity generation installations of between 1MW and 100MW.

The MMO together with others, including marine regulators, renewable energy trade organizations, nature conservation bodies and consultants, recently helped develop guidance for The British Standards Institution on best practice for undertaking EIAs for offshore renewable energy installations.

Pelamis wave energy converter located in Orkney. Image: S. Nicholson.

The guidance synthesizes best practice for EIAs and covers several traditional areas (screening, scoping, cumulative effects assessment and production of the Environmental Statement), together with comparatively recent methodologies including the preparation of preliminary environmental information (PEI), evidence plans, and in-principle monitoring plans The PEI, for example, sets out how developers will consult with stakeholders, including the local community and the various interested parties, while in-principle monitoring plans ensure a commitment by all parties to streamline post-consent condition discharge.

In the UK, there is a strong policy drive for offshore renewable energy development and Government recognizes the need for new infrastructure to be consented and built with the objective of contributing to a secure, diverse and affordable energy supply. The EIA guide together with other initiatives, including recent reviews aimed at improving the efficacy of post-construction monitoring and evidence base, will help to reduce consenting uncertainties for offshore renewables and will go some way to providing more robust EIAs and reducing barriers to consent.

Dr Shaun Nicholson Mem. MBA (shaun.nicholson@marinemanagement.org.uk) is Head of Marine Licensing at the MMO. Greg Tomlinson (greg.tomlinson@marinemanagement.org.uk) is a Case Manager at the MMO focusing on major infrastructure projects. Ross Hodson (ross.hodson@marinemanagement.org.uk) is a Senior Marine Licensing Manager at the MMO and leads on renewable energy projects.

FURTHER READING

British Standards Institution (BSI) (2015). Environmental Impact Assessment for Offshore Renewable Energy Projects – Guide. BSI Standards. Available from: http://shop.bsigroup.com/forms/PASs/PD-6900/

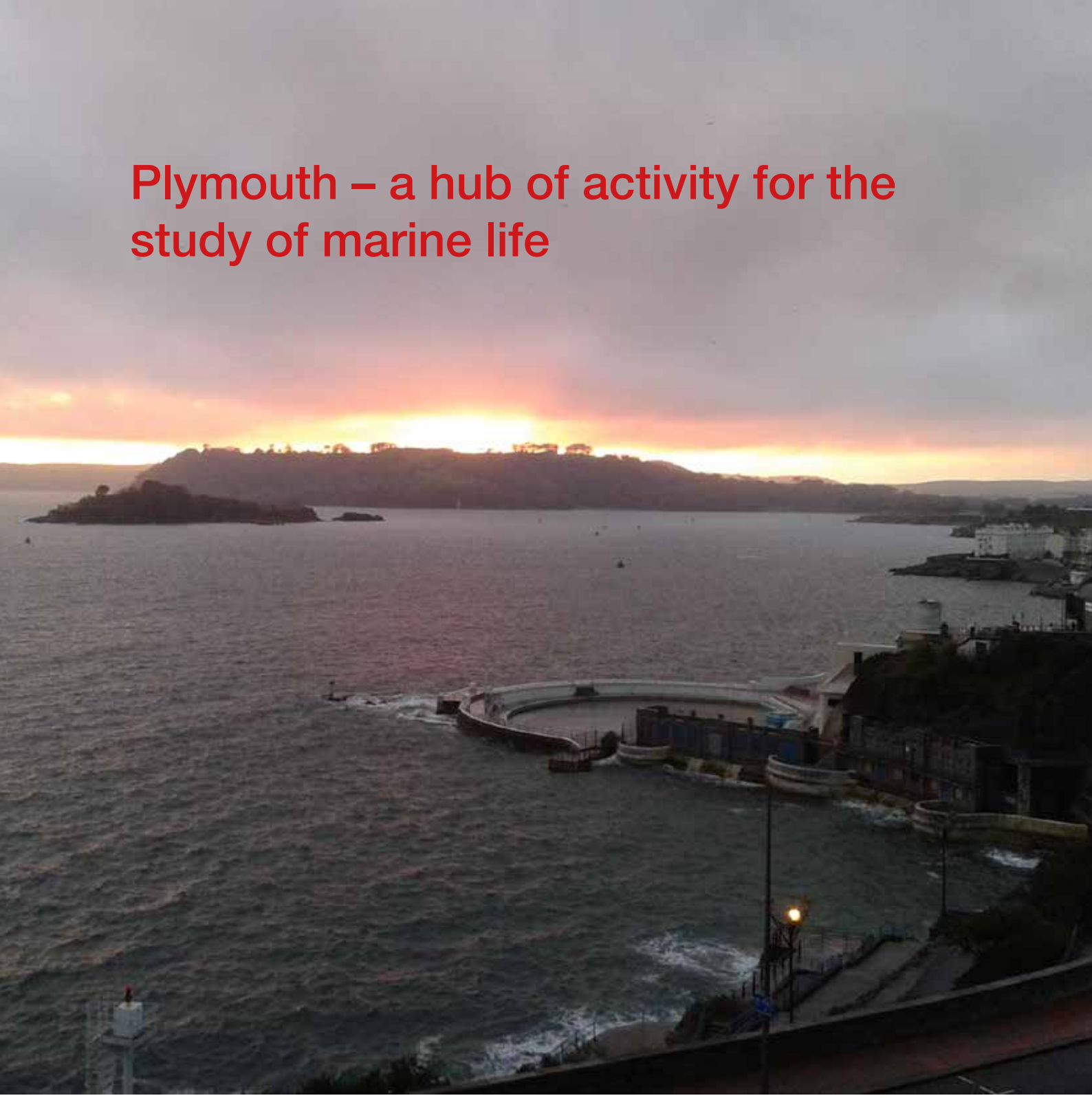
Department of Energy and Climate Change (DECC) (2011). National Policy Statement for Renewable Energy Infrastructure (EN-3). Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/37048/1940-nps-renewable-energy-en3.pdf

The European Wind Energy Association (EWEA) (2010). Wind Barriers – Administrative and Grid Access Barriers to Wind Power. Available from: http://www.ewea.org/fileadmin/files/library/publications/reports/WindBarriers_report.pdf

Marine Management Organisation (MMO) (2014). Review of Environmental Data Associated with Post-consent Monitoring of Licence Conditions of Offshore Wind Farms. Available from: http://www.marinemanagement.org.uk/evidence/1031.htm

Nicholson, S. (2014). A review of post construction monitoring at UK and European offshore wind farms: Key findings and recommendations for future monitoring of birds and marine mammals. *The Habitats Regulations Assessment Journal* Issue 2, July 2014: 15–17.

Plymouth – a hub of activity for the study of marine life



Plymouth is a unique place to study marine biology. Professor John Spicer outlines why.

Why is Plymouth so important for marine biology?
Plymouth certainly has a long and distinguished history of marine research. The place and the people have attracted scientists from all over to work here. Over a century ago the Marine Biological Association decided to locate their laboratory here identifying Plymouth as the best site to study marine biology. And that has not changed. The Sir Alister Hardy Foundation for Ocean Science, Plymouth Marine Laboratory, the Diving Diseases Research Centre, and the National Marine Aquarium are all based here and have excellent links with Plymouth

University. The surrounding area boasts incredible rocky and sandy shores, and probably the greatest concentration of different types of estuary in the UK. Plymouth really is a hub of activity for anyone interested in marine life.

Why Plymouth University for marine biology?

You might expect me to attempt to dazzle you with our amazing facilities and infrastructure. I could do that – £19 million for our new marine building and £4.65 million for our new Marine Station on the shores of Plymouth Sound, a 25-minute walk from campus, and located beside the National Marine Aquarium; all pretty impressive for starters. But that is not where I would begin.

The aim of the marine biology degrees at Plymouth is simple. By the end of the degree programme each student will have had the opportunity to acquire the academic knowledge and practical skills to experience what it is like to be a practising marine biologist. Whether they decide to stay on for further study or research, as many do, or change direction and go into accountancy, business, television, banking or management, all our students will know what it is to be a marine biologist. Good infrastructure and equipment are vital to 21st Century science, but infrastructure does not do science – people do.

So, why should *you* study marine biology at Plymouth University?

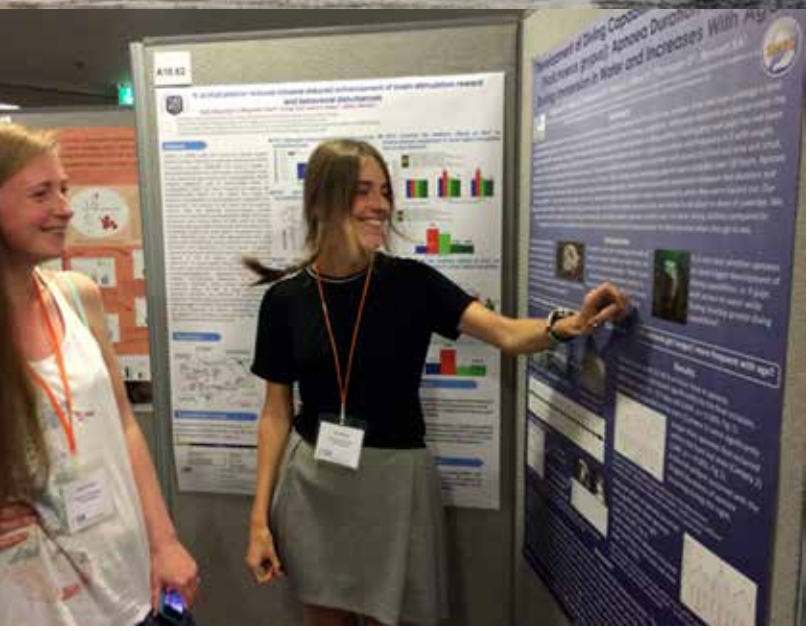
I would say because you would be part of a group of highly motivated and well qualified students—young, old, from the UK or overseas—all passionate about their subject. Because the course has been carefully tailored to achieve our aim – academic and practical work providing the 'tools' for the practising marine biologist. Because we have staff who are passionate about their subject, and about passing their knowledge and passion on. Educators yes, but also research active, able to bring you cutting edge science – much of it from Plymouth. And last (but not least) the physical and intellectual environment, the most amazing marine habitats literally on our door step and what must be one of the greatest concentrations of marine scientists in Europe. Many of our students volunteer or carry out their Honours projects with these institutions.

What does marine biology at Plymouth 'look like'?

There are three marine biology (BSc Hons) degrees. They cover the same content but each has its own flavour. Marine Biology focuses on the organisms of the sea – starting with the individual we look up to their ecology and down to the molecular and cellular levels. Marine Biology and Coastal Ecology covers much of the same ground but takes a more cross-systems approach, in which ecosystems and interactions take centre stage. Finally, Marine Biology and Oceanography integrates biological knowledge with an understanding of ocean processes.

During the first year, students get to grips with key biological, ecological and oceanographic themes, with topics ranging from biodiversity and ecosystems to evolution and even microbiology. The actual content varies between the

Top: Marine Biodiversity – first year students examining a preserved cephalopod. Image: John Spicer. Bottom: Examining the fauna of a man-made structure during the Experimental Marine Biology Field Course to Portugal. Image: Richard Thompson.



Top: The New Marine Station on Plymouth Sound. Image: Plymouth University.
Bottom: Final year student Darcy presents results from her Honours project at the Society of Experimental Biology, Prague. Image: John Spicer.

different degrees. Through a mixture of lectures, small group tutorials, laboratory and fieldwork you will begin to acquire skills giving you a firm base for being a practising marine biologist – they will also boost your employability and help your career development. The residential field course abroad puts you at the centre of the process of scientific investigation, data collection and analysis. You attempt a mini-project—you identify an important question and chase that using an experiment you have designed—a foretaste of your Honours year.

In the second year, things step up a gear. The content increases and is specific to your degree but you sharpen your practical skills often in the setting of the South Devon coastline, just minutes away. There is a second overseas residential field course. There is more on methods for collecting, handling and analysing scientific data, building on what you mastered in the first year, particularly during the field course. Taking a 'year out' is possible, an opportunity for a 6–12 month work placement. Alternatively a work-based learning module can run alongside your studies. Both can significantly improve your skills set and employability.

Your final year is the opportunity to focus on your chosen area of study. You conduct an extensive personal research project, applying the skills and methods you have learned in the previous two years – currently 11% of these projects are published, in full or part, in international, peer-reviewed scientific journals. There is also a range of modules to choose from, each reflecting the research interests of staff, all beyond the text book and at the cutting edge of the subject.

So that's what I say. But what do the students say?

"*I actually came all the way from Germany … Plymouth Uni is a great place to study, I'm really happy I came here. It gives you the knowledge and the practical skills that you really need … and this feeling that you're ready to go out there and be a marine biologist*". (Kathy, Final Year Student)

"*I picked Plymouth University because I knew it was the place for marine biology. There is so much going on here … to be involved in ongoing research is a fantastic experience. It's a really vibrant community and gives you that buzz when you are surrounded by it and it really motivates you to get involved in your own scientific research. It's a very hands-on course. Lecturers give you lots of experience in lab work and fieldwork … I'm interested in the fisheries aspect ... I spent my summer diving, being out on trawlers and that is real practical experience that I can put on my CV … it stands you in great stead for your future career*". (Henry, Final Year Student)

The 2015 National Student Survey reported that 97 per cent of respondents found the course intellectually stimulating and 97 per cent were satisfied with the course overall. But the bottom line is, if you really want to know what it is like to study here, come and talk to our students. Visit us at one of our open days.

Professor John Spicer (jispicer@plymouth.ac.uk) School of Marine Science and Engineering, Plymouth University

Young Marine Biologist: a new and popular way to join the MBA!

If you are under 18 and interested in marine life, joining the MBA as a Young Marine Biologist (YMB) is the perfect way to learn about marine biology and engage with other like-minded individuals around the world. Membership comes with great benefits such as: discounted training courses and conferences; discounts on books and outdoor gear; and twice-yearly copies of *The Marine Biologist* magazine. Joining also demonstrates your enthusiasm for marine biology and improves a CV or personal statement.

YMB is proving to be extremely popular and numbers are increasing all the time. As a result, we are planning to introduce further benefits, for example, we are now offering YMB Bursaries to help you attend marine biology related conferences, meetings and events. You can apply for these bursaries online.

The membership fee for YMB is only £12.50 per year, making it a perfect gift. The welcome pack includes careers information and a free beach bag, with renewing members currently receiving a multi-use MBA snood.

Through our regular bulletins, especially aimed at a younger audience, we keep our members informed of marine biology events, our annual work experience week, special offers, competitions and the ever-popular '*Marine Biologist for a Day*' held at the MBA laboratory during British Science Week.

Contact us to learn more, or visit our joining page at: www.mba.ac.uk/membership/join

Jack Sewell (jase@mba.ac.uk)

Things I wish I'd known as an undergraduate

Studying and working in the field of marine biology is fascinating and immensely rewarding. However, this also means that it is highly competitive, and finding work can seem an insurmountable task for the recent graduate or aspiring marine biologist. I am about to finish my Masters in Tropical Marine Biology and have been lucky enough to have worked and volunteered in several roles related to marine science. I would like to share a few things I wish I had been told when I was first dipping my toes into marine biology:

1. Volunteering doesn't have to cost an arm and a leg

Many employers value relevant work experience above qualifications and volunteering is a great way to get it. Not everyone has the money to spend three months volunteering in Fiji or Thailand, but many relevant volunteering opportunities can be found much closer to home and free of charge. If you are lucky you might even get paid! In 2014 I volunteered with seven different organizations in the UK, from a European eel monitoring project with ZSL to the cetacean-themed event WhaleFest in Brighton. In doing so, I have made valuable contacts and the experience has really boosted my CV. I only wish I had started before graduating. If you are on the lookout for volunteer opportunities, www.environmentjob.com is a good place to start.

2. Network wherever you can

You have probably been lectured on the values of networking already, but it is worth taking seriously. Again, this is something I wish I had begun as an undergraduate. Marine biological conferences are fantastic places to mingle with established researchers and find out more about different branches of marine biology – many conferences also have dedicated workshops and activities for students. Be brave and seek out chances to meet people and network; these are likely to be the people reading your future job applications, and marine biologists are generally a friendly bunch! Conferences are also great places to share your research, meet potential future collaborators and swap ideas for projects.

3. Don't specialize too early

Your passion may be for marine mammals or even extremophilic microbes, but it is a good idea to keep your interests broad while you can. If you choose to enter academia as a career, your research interests will inevitably narrow. For this reason, using your undergraduate degree and free time to learn about fields of marine biology you might not have come across before is a good idea. Versatility is also desirable when job-hunting.

Amy presenting her research at the MBA Postgraduate Conference at Queen's University Belfast in May 2015.

I hope these tips will prove useful. The most important thing to remember is to be persistent and remain enthusiastic in your quest to break into marine biology.

Amy Wright (arwrig@essex.ac.uk)

Little-known giants of the plankton

Sinazo Mophlo and Mark J Gibbons

As zooplankton go, scyphozoan jellyfish are behemoths and include amongst their number the East Asian *Nemopilema nomurai,* which can reach a diameter of up to 2 m and attain a weight of 200 kg. Although not all scyphozoans are as massive as the Sumo wrestler-like *Nemopilema*, they are all significantly bigger than their fellow drifters such as copepods, chaetognaths or euphausiids. Given their large size, one would expect them to be well understood and their taxonomy to be well resolved. However, nothing could be further from the truth. Their large size and fragile nature means that rigorous experimental studies are few and far between; their pelagic habitat and drifting lifestyle means that repetitive field studies can be costly and hit-and-miss, which translates into the fact that, with the exception of the moon jelly *Aurelia*, good field studies are scarce. Their simple and conserved morphology also means that identification is often subjective and cryptic species appear to be common. The lack of hard parts means that we really struggle to estimate longevity in the field whilst their ability to shrink and regrow means understanding patterns of growth is near-impossible. We do not even know whether they are serial spawners or batch spawners! And the fact that they do not even have a sealable gut means that our quantitative understanding of *in situ* feeding is, frankly, little more than guesswork.

Southern Africa (Namibia and South Africa) is a case in point. The formal scientific literature describes a total of 11 species from this region (see Table 1 at www.mba.ac.uk/marinebiologist/giants-of-the-plankton), a number that represents a mere 5 per cent of the suspected global species pool. This value is less than half that observed for the much smaller Hydrozoa with similar life-history strategies. Indeed, of the roughly 1,000 mero- or holo-planktic Hydrozoa, around 280 are known from regional waters. Part of the reason that we know so much more about hydrozoans is precisely because they are much smaller – hydromedusae are, for the most part, similar in size to other plankton and they routinely get caught and collected during oceanographic and fisheries surveys. The other reason that we know so much more about hydrozoans around South Africa is that Naomi Millard devoted a large part of her life to this group. Nobody has made a consistent career of regional Scyphozoa – though here at the University of the Western Cape, a small group of enthusiasts is trying, with support from the National Research Foundation's SEAKeys Project!

Whilst the numbers of professional scientists on the ground in southern Africa appears to be only slightly larger now than it was some 50 years ago, the community of scientists in the 21st Century is happily being augmented by enthusiastic citizens. Through their photographs, some of which are shown here (Figure 1), we have managed to increase the number of morpho-species from 11 to the much healthier 20 (Table 1). Although this translates to around 10 per cent of the suspected global species pool, it still represents less than half that observed for Hydrozoa. But, we have only just started getting photographs together and our lives are ahead of us …

The trouble with photographs is that unless they are of high resolution and focused on diagnostic anatomical features, it is next to impossible to be 100% certain of a specimen's identity. That may not be such a big deal in a system where there are only a handful of species and the known species are clearly different. But when there may be many similar species, cryptic species or when there are a lot of unknown species, the low resolution shots of divers taken with an emphasis on aesthetics and memories become difficult to use. Hence we refer to them as morpho-species until such stage as we have good specimens at hand and have collected the all-important DNA.

The preliminary data show a couple of interesting things. There are a large number of Rhizostomeae along the east coast and relatively few along the west coast. This is perhaps not really surprising as this group of jellies is considered to be of Indo-Pacific origin, and these species get transported

Fig. 1a. *Thysanostoma* sp. Image: Eve Marshall.

Photographs of Scyphozoa submitted by citizen scientists for identification. All images represent new morpho-species for the region. Opposite: Fig. 1a. *Thysanostoma* sp. (Eve Marshall). Above: Fig. 1b. *Cephea* sp (Vegard Kvam); 1c. *Chrysaora* sp X (Craig Foster); 1d. *Rhizostoma* sp. Image: Craig Foster. All images remain the property of the photographers.

around our coast by the most intensive western boundary current in the world, the Agulhas current. Some of these Rhizostomeae are clearly vagrants (*Phyllorhiza* sp., *Cephea* sp., *Thysanostoma* sp. and *Rhopilema* sp.), as evidenced by the few records. But some probably have local populations, if temporally repeat observations from similar locations are anything to go by. This list includes *Crambionella stuhlmanni* and a species of *Catostylus*, both from estuarine environments, as well as *Eupilema inexpectata*. The latter species is a known endemic, and it is not unlikely that the unidentified species of *Catostylus* will prove similarly African. Two morpho-species of *Rhizostoma* are obvious in the photographs – one with very long, purple terminal clubs which appears to be more prevalent along the south-east coast, and another with shorter colourless clubs that is more common along the south and west coasts. It is possible that the former corresponds to *Rhizostoma luteum* whilst the other maybe *R. pulmo* – but only the genetics will tell.

Two species from the same genus is interesting but to have three is fascinating. And that is what we find in the genus of compass jellies, *Chrysaora*. The 40 tentacle *Chrysaora africana* extends from the Gulf of Guinea through to Namibia and the northern part of the South African coastline, the 24 tentacle *C. fulgida* extends from southern Angola through to just east of Cape Agulhas (the southern tip of Africa) while a new species, *Chrysaora* sp. X, also with 24 tentacles has a range that encompasses the width of the south coast (from Cape Town to Port Elizabeth). It too is endemic, if the genetics are anything to go by and it appears to be closely related to *C. fulgida* but when and why it split from the latter provides food for future thought.

South Africa has a coastline length of about 2,800 km, and Namibia's coast spans a distance of 1,600 km. That is not very long, all things considered. The United Kingdom has a coastline length of about 12,430 km, and if you were to unwrap Japan or Australia, they would stretch for 29,750 and 25,760 km respectively. So, 20 species along a coastline length of 4,400 km makes South Africa one of the, if not *the*, most species dense country in the world as far as Scyphozoa go. The reasons for this are not hard to understand, because the region is bathed by two different water masses, it spans a number of distinct biogeographic provinces and hosts a myriad of distinct biomes and ecosystems from coral reefs and mangroves through to coastal upwelling areas.

Fig. 2: In celebration of jellyfish! Sheet of postage stamps released by the South African post Office. Artist: Sheila Collins; Copyright: South African Post Office.

To celebrate South Africa's rich diversity of Scyphozoa, the South African Post Office has released a set of postage stamps featuring many of the more common species (Figure 2). To the best of our knowledge this is a global first and if nothing else it will serve to introduce the region's citizens to, and educate them about, the giants of the plankton.

Sinazo Mophlo and Mark J Gibbons (mgibbons@uwc.ac.za) Department of Biodiversity and Conservation Biology, University of the Western Cape, Private Bag X17, Bellville 7535, Republic of South Africa.

Science advances for shark conservation

Sharks, skates and rays, known collectively as the elasmobranchs (literally 'plate-gills'), are cartilaginous fish that are important predatory and scavenging species within aquatic ecosystems. However, life-history traits such as slow growth, late maturity and low fecundity make them less resilient to exploitation than many bony fish. There are current concerns that target and by-catch fisheries for many elasmobranchs are depleting populations below sustainable levels.

These concerns and the need for science to inform conservation measures provided the backdrop to the Fisheries Society of the British Isles Annual Symposium on the 'Biology, Ecology and Conservation of Elasmobranchs' that took place in Plymouth on 27–31 July 2015. The meeting was convened by Marine Biological Association (MBA) ecologist David Sims with assistance from scientific advisory and organizing committees. A key aim was to explore how new scientific and technological approaches, such as biotelemetry, biologging and genomics, can contribute to improved conservation.

And what an inspiring and engaging meeting it turned out to be. The symposium welcomed 170 scientists from 34 countries (pictured, below), with 85 speakers, 39 of whom were women, and an impressive range of ages represented, from undergraduates to emeritus professors. It was immediately obvious that elasmobranch biology and ecology is blooming as a diverse and vibrant field of science.

The entire meeting was filled with excellent talks and stimulating discussions, with many highlights. Dr Gregory Skomal of the Woods Hole Oceanographic Institution described new underwater robots developed to track the fine-scale movements and predation events of white sharks. A great Keynote talk was delivered by Dr Kevin Feldheim of the Field Museum of Natural History, Chicago, on how genetic tools are revealing hidden truths about sharks; for example, the first evidence that the female lemon sharks return to give birth in the lagoon where they themselves were born. Such insights are vital for conservation efforts seeking to protect critical habitats.

A key question in elasmobranch biology that is crucial to population assessments for management is how old do sharks, skates and rays get? The Keynote talk by Prof Gregor Cailliet from Moss Landing Marine Laboratories in Monterey, California gave a thorough retrospective on the research underpinning this question. He presented work highlighting various validation studies that he separated into 'the good, the bad and the ugly', enhanced of course by a musical interlude of the Ukulele Orchestra of Great Britain playing Ennio Morricone's classic (do check it out on YouTube).

The focus on conservation biology was especially stimulating. An excellent Keynote talk by Dr Julia Baum of the University of Victoria in Canada highlighted the plight of sharks on coral reefs, and how important it is to have in place long-term data collection to track abundance changes. And there were authoritative presentations from conservation practitioners, particularly Sonja Fordham of Shark Advocates International, Washington, DC, who described the successes and the many challenges that lay ahead in terms of science-led global conservation of elasmobranchs.


Oceanic whitetip (*Carcharhinus longimanus*) Image: J. Stafford-Deitsch.

In addition to cutting edge science, there were also social events for the international delegates to meet for in-depth discussions. The Icebreaker drinks reception at the MBA was sponsored by Plymouth Gin, ensuring it went with a swing.

So what were the conclusions of the 5-day conference? Many elasmobranch populations are in decline, ranges have contracted for some and there are no regulations to control fishing for many species. However, the global community of elasmobranch researchers and conservationists is growing fast, and they are working together to influence policy more effectively than ever before. And the application of technology is revolutionizing the way we can view shark movements, map whole populations, and use forensics to identify species caught illegally. The future may be looking brighter.

The symposium was also taken to the world via Twitter. You can follow the meeting as if you had been there by visiting #FSBI2015.

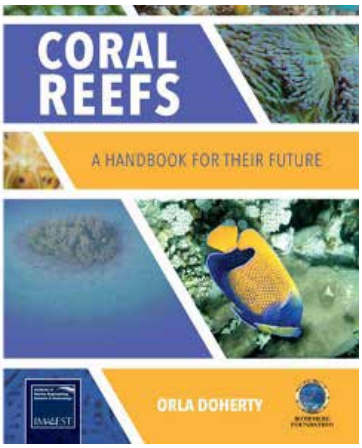
David Sims dws@mba.ac.uk (MBA Senior Research Fellow). Samantha Simpson samsim@mba.ac.uk (NERC PhD Student, MBA and University of Southampton).

Reviews
and new titles

CORAL REEFS: A Handbook for their future

Author: Orla Doherty
ISBN: 0956560091
Published by: IMarEST

In the coming decades, climate change is just one consequence of man's influence on the environment which will change the face of the earth, as well as the lifestyle of mankind and many other species and ecosystems on the planet. One of those ecosystems is the coral reef, often called 'the rainforest of the ocean'. This beautifully presented book, produced in a collaboration between the Biosphere Foundation and the Institute of Marine Engineering, Science & Technology, takes the reader through an exploration of coral reef biology, and looks at some of the challenges, both practical and moral, including climate change and global warming, that we face in trying preserve one of the most important ecosystems on the planet.



Global warming is nothing new, although the name has changed over the years. In 1824, the great French natural philosopher Jean-Baptiste-Joseph Fourier, who had escaped the guillotine four times, published an article showing that the invisible dome that is the atmosphere absorbs some of the Sun's warmth and reradiates it downward to Earth's surface. In the 1890s, the Swedish chemist Svante August Arrhenius realised that the large rise in fossil fuel consumption resulting from the Industrial Revolution could contribute to the natural global warming by the sun, as the emitted gases would trap more heat, causing the temperature to rise. He called this a 'hothouse' effect; much later it would become known as the 'greenhouse' effect.

This book celebrates that coral reefs are marine ecosystems of great biodiversity that are very sensitive to climate and changes to their environment, and does it in a manner that is delightfully easy to read. A major feature is the colour photography, many of the 422 images were presumably taken during the 18-year 'Planetary Coral Reef expedition' (1995-2008). This was a project initiated from the ill-fated Biosphere-2 project in Arizona by the Biosphere Foundation to provide baseline data about the health and vitality of the world's coral reefs. At the end of the voyage, data analysis showed that two-thirds of the 49 reefs monitored were at risk.

After an introduction as to why coral reefs are important, there is a section on coral reef evolution, including the five mass extinctions that have occurred on the planet to date. There are then short chapters on coral reef types, the physiology of coral growth, and their reproduction. The major part of the book covers the various coral reef organisms from invertebrates through fish to vertebrates. I was pleased to see that coral reef plants—including mangroves and seagrass—were also included.

The third part of the book details threats to coral reefs, including natural, local, human and climate change. For a book subtitled 'A handbook for their future', I was disappointed that this section was predominantly descriptive, with little analysis or indication of how reef managers or even tourists could help improve matters. If the book runs to a second edition, I would like to see this section expanded. There is, however, a short, three-page section entitled 'What you can do to make a difference' which included reusing, recycling, and using sustainable seafood guides when eating fish.

The book has a 1-page bibliography but no Index. I was sometimes frustrated by the lack of detail, both in the text and in some of the larger photographs, which can lack detailed resolution. However, as a highly readable overview of coral reefs, and the threats they face, it is unsurpassed.

Education is one approach to try to connect the "future perspective" mismatch between conservationists from developed countries and indigenous people who live by the reefs. This book is a highly polished tool to help in coral reef education at all levels.
Professor M James C Crabbe MA, BSc, MSc, PhD, DSc, FIBiol, FRSC, FRGS, FRSA, FLS, FIMarEST

Whales, Dolphins and Porpoises

Author: Annalisa Berta
ISBN: 9780226183190
Published by: University of Chicago Press

On the 24th August 2015 a blue whale was sighted 250 miles off the Cornish coast. Like many of the cetaceans that swim our waters, blue whales have a mammoth migratory range, occurring in every one of the world's oceans. In the past this was one of the challenges in studying cetaceans but advances in technology have uncovered a whole new understanding of what is going on beneath the waves. Covering over 90 species of cetacean, *Whales, Dolphins and Porpoises* combines the latest studies on the nature and behaviour of these elusive creatures to produce a wonderful and comprehensive species guide for everyone to enjoy.

Annalisa Berta takes the reader on a

beautiful journey which begins with the natural history of whales, dolphins and porpoises. This is followed by a guide to 90 species of cetacean which assumes no prior expertise. Every turn of the page introduces a new species, each one beautifully illustrated and covering every minute detail from dive sequences and fin shapes to unique markings. Annalisa has opened up a whole new underwater world by sharing the most recent scientific advances on feeding, mating, and communication of these animals helping us to understand a little more about their hidden lives.

Too big for a field guide, but perfect for a coffee table, this beautiful book is best enjoyed slowly. I recommend learning one species every night. You will be an expert in 90 days!
Harriet Yates-Smith

Ocean Film Festival UK Tour

www.oceanfilmfestival.co.uk/#!/home
Presented by: Surfdome

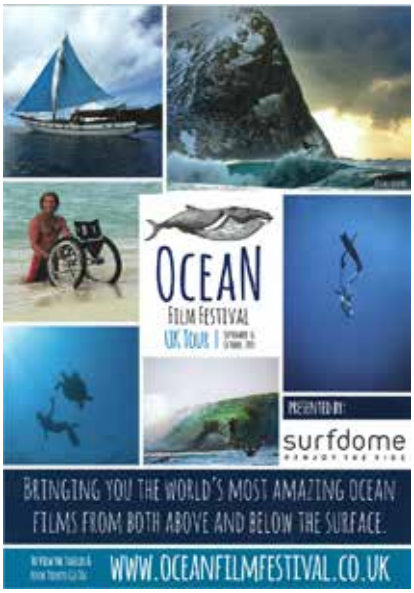
Breezing late into a full house I muscled apologetically to my seat past assembled ocean lovers – salty, hairy and levered into their best clobber for a night at the cinema. Seven films were screened falling into two broad categories - those dealing with the human spirit through the medium of ocean-related antics, and those with a conservation message.

First up, *The Fisherman's Son* tells the story of Ramon Navarro from his roots as the son of a subsistence fisherman in rural Chile to professional surfer, plotting a tangible path from a child raised with an appreciation and respect for the ocean to conservation champion. Ramon has used his celebrity in his home country to gain support for successful campaigns and is spearheading a progressive conservation initiative to protect his own home surf break, Punta de Lobos. An impressive film with some cool aerial shots and an intense guitar soundtrack to accompany Ramon's power surfing.

Arctic Swell is also a film about surfing, but in contrast to the multi-dimensional '*Son*' it stops there. It is basically privileged people surfing in beautiful, cold places in expensive wetsuits in which cold water surf photographer Chris Burkard overstates the niche he's created for himself. Whilst the cinematography and scenery are beautiful it is just another surf film.

Devocean is a matter-of-fact film about impressive strength and resolve, and the ocean giving someone another chance at a life lost, telling the story of South African Bruno Hensen who was tragically paralysed from the waist down in a car-jacking. The film illustrates an incredible transition when he's in the water with his 'upright' mates, as the disability ceases to define him and he's able to move as an equal with relative ease and grace. After the film, Bruno appeared on stage to a standing ovation; ironic in the circumstances.

Ocean Minded delves on a single breath into the world of freediver-come-conservationist Hanli Prinsloo, following her on an enviable shark and dolphin odyssey up the coast of her native South Africa from Cape Town and into Mozambique. Moments of the film are excruciatingly cheesy such as the slow motion hair flick from under water.



However, in a time of near shark hysteria in the media, Hanli presents the only logical response to water users who would have sharks culled so that they can indulge their hobbies – it's their domain (just stay out of their 'kitchen and dining rooms').

A short film followed about a lovable skinny-dipping Norwegian man named Ulf, who makes a traditional jack-of-all-trades wooden boat with impressively sharp tools. A heart-warming short about a six year-old Aussie girl 'The Flying Squirrel', with a lifelong illness and a huge natural talent for surfing and skating, left me feeling a huge admiration for her brave and encouraging parents. A good point is made in a brief and novel animation about the out-of-sight, out-of-mind attitude mankind can have towards the sea.

It was a good night out which explored different versions of the same overall bond with the sea. I'm sure all the saltyphiles in that room could relate to in their own way – personally I like it any way I can as long as it's not misty-eyed and overstated.
Seán O'Hea

The Controversy Over Marine Protected Areas: Science Meets Policy

Authors: Caveen, A., Polunin, N., Gray, T., Stead, S.M.
ISBN: 3319109561
Published by: Springer Briefs in Environmental Science.

This book is essentially an extended 'viewpoint' article that especially addresses whether marine reserves (MRs) have been a successful tool for the management of fisheries. Incidentally, it seems, the book addresses protection of biodiversity.

The authors use of the term 'marine reserves (MRs)' is copied in this review but I do not believe that the book uses the term in the manner that most conservation scientists now use it, i.e. to refer to highly protected areas. 'Marine protected areas (MPAs)' is the more commonly used generic term for all sorts of protected areas and the authors fail to make clear that many 'MRs' (really MPAs) have management measures that do not affect fisheries in their area.

The authors address issues in terms of coming from 'Nature Protectionists' (NPs) versus those from 'Social Conservationists' (SCs) and offer the reader a storm of quotes from scientific papers, newspaper articles and so forth. The NPs get the dirty end of the stick in this book (and sometimes deserve it) but the conclusion must be that sometimes they 'win' and sometimes the SCs 'win'.

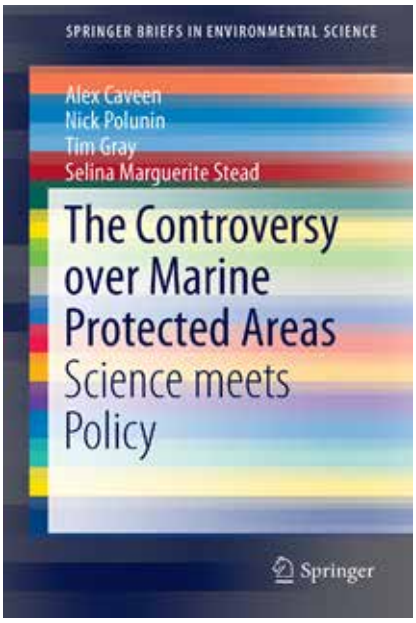
The book refers specifically to the conflict between use of traditional fisheries management measures against MRs as tools for both fish conservation and biodiversity conservation; i.e. a very narrow part of the wide field of marine conservation. If conventional fisheries management has indeed failed to protect fish stocks (the decline in fish stocks is acknowledged) whether or not MRs will improve prospects on the scale of regional seas is as yet unproven because so few have been established that prohibit all fishing over sufficiently large areas. In this context, I was surprised not to see reference to the very good report to the European Parliament by Roberts and Hawkins in 2012 on 'Establishment of fish stock recovery areas'.

The title of Chapter 2 ('The rise and rise of the marine reserves 'bandwagon') will make the reader suspicious that marine reserves are going to be criticised and, sure enough, in the conclusions: "However, the opponents of MRs belatedly responded to these pro-MR networks and established anti-MR AC [Advocacy Coalitions] to challenge what appeared to be an inexorable move to impose MRs across the world's oceans, and this challenge seems to have slowed down the MR juggernaut at least temporarily."

The 'Bibliometric test' (Chapter 3) is an interesting exercise that concludes "emphatic confirmation of the MR 'bandwagon'" because: MR publications dominated the marine management literature; 90% of MR researchers are marine ecologists [rather than fisheries biologists]; MR publications have been highly influential amongst marine scientists, and that MR research has likely attracted more funding that any other subject area of applied marine sciences.

In Chapter 4, whether there is a pro-MR bias amongst authors and journals is investigated. Evidence seems largely anecdotal but the inference is clearly made that there is.

Chapter 5 (a critique of the scientific evidence for fisheries benefits of MRs) is good background information but



perhaps does not make the point strongly enough that the proven benefits of MPAs are largely for commercially (or recreationally in some cases) fished species, albeit in mostly small areas, and the benefits for seabed biodiversity and non-target species are poorly known.

The discourse analysis of the MCZ process in England (in the provocatively titled Chapter 6 'The English Patient') suggests that there was confusion over the objectives that MCZs were being designated to achieve. Although MCZs were always a measure for the conservation of benthos and especially habitats and low-mobility species, there were, as drawn attention to in the book, some influential individuals who were confused about the prospects of MCZs for protection of commercial fish stocks. The book quite rightly criticizes some of the exaggerated claims of journalists for the importance of MCZs and pleads for factual accuracy – something that journalists have never been good at! That the MCZ process took very full (some would say too much) account of socio-economic considerations is, it seems, forgotten or denied in text that seems intent on rubbishing the process. In particular, it is irritating that so much credence is given to the MPA Fishing Coalition (referred to as MPAC - Marine Protected Area Coalition – i.e. not mentioning that it is a fishing coalition) as theirs was clearly an anti-MPA advocacy group. The text draws attention to the unfathomable meaning of the overarching goal of 'an ecologically coherent network' but, perhaps, doesn't go far enough in criticizing those who continue to use it as a starting point for the identification of MPAs. The 'Conclusions' could have better been a 'Lessons learnt'.

Chapter 7 is entitled 'Conclusion' but is a summary of the contents of the book and includes a useful discussion of the role of scientists and stakeholders in determining or influencing what conservation measures might be most effective. However, it is, again, a storm of quotes and arguments that leave the reader wondering "so, what is the conclusion?". There is a 'Conclusion' section at the end of the chapter but it is a single paragraph and does not guide us to what measures are most appropriate for different objectives.

This book is a summary of where we were in 2014 in understanding the value of MRs for fisheries conservation and, to a lesser extent, for biodiversity conservation: it should be read by all MPA practitioners and students, even if it does make uncomfortable reading in places. It seems a pity that the authors have pitched their arguments in such black and white terms: MRs (MPAs) have their place as do wider measures for both fisheries and biodiversity conservation. All-in-all, the book lacks 'take-away' conclusions that might inform the way in which the seas may be protected from the adverse impacts of human activities.

Keith Hiscock

Erratum

The article, Frost, M., 2015, The MBA National Marine Biological Library: Changing Times, *The Marine Biologist*, 4: 28, was co-authored by Barbara Bultmann (barbue@mba.ac.uk) Library Services Manager, National Marine Biological Library (NMBL).

Interview

Murray Roberts is a Professor of Marine Biology in the School of Life Sciences and Director of the Centre for Marine Biodiversity & Biotechnology at Heriot-Watt University where he leads the Changing Oceans research group. He discovered the Mingulay cold-water coral reef complex off Scotland and played a key role in establishing the new Sir Charles Lyell Centre.

***TMB*: How did you become a marine biologist?**

MR: I was always crazy about natural history but I grew up in suburban London so I had to go looking for nature. I volunteered at the Chelsea Physic Garden and with BTCV [now the Trust for Conservation Volunteers]. My marine epiphany was a holiday in the Channel Islands when I discovered snorkelling – that was it; I was face down in the water for a week!

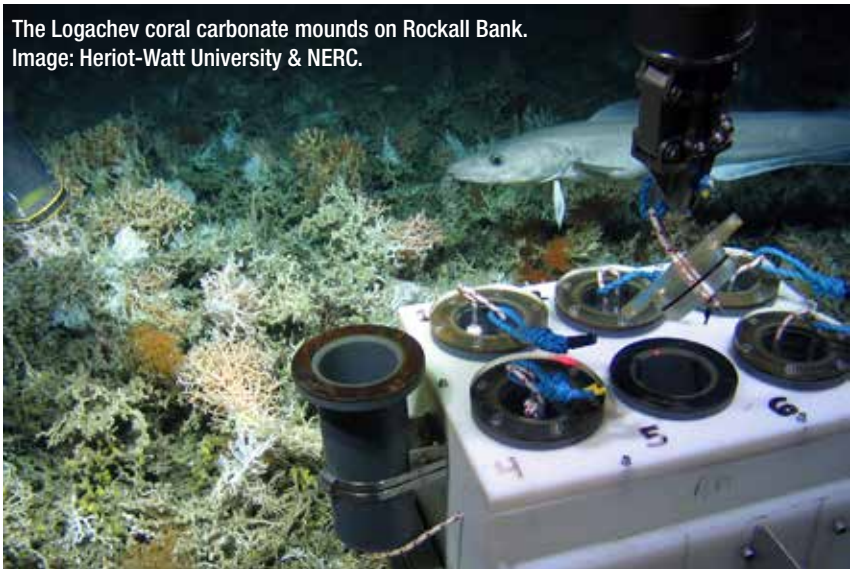
While studying biology at York University, I took a year out to look at my options. I needed to start earning so I took a sandwich year working at the drug company Lilly Research in Surrey. Back at York I was one of a group of undergraduate students who planned and designed experiments for a 5-week expedition to Sinai. Through diving and snorkelling surveys I recorded the interactions of damsel fish with their habitat. I sub-sampled for genetic analysis but as you can imagine with limited facilities there were sample preservation issues! Despite the practical challenges, our group managed to put out a research paper. We were camping in some squalor subsisting on biscuits and fish when a group of students from Glasgow led by Peter Spencer-Davies came by. I took a lift on the bus to visit the local Bedouin fishermen and I got talking to Peter who happened to have a PhD going at the University of Glasgow. My PhD examined nitrogen cycling in the *Anemonia viridis* symbiosis. This anemone turned out to be a particularly tractable model organism and of course had much relevance to the biology of corals which was to become a theme in my career.

***TMB*: What do you study and why? What questions are you trying to answer in your research?**

MR: After my PhD I began a postdoc with John Gage working on the ecology and biodiversity of cold-water corals, leading onto investigations of ecosystem history, connectivity, vulnerability to change and the services these corals provide in the deep ocean. Now, we are looking at ocean acidification and warming as the dominant stressors of these ecosystems. After around 10 years at SAMS [Scottish Association for Marine Science] I was awarded a Marie Curie Fellowship in the US researching *Lophelia* occurrence off the Carolinas and Florida and linking this to the North Atlantic development of these habitats over time. This was a wonderful opportunity which included work on board the submersible *Johnson Sealink*, and was where it became clear to me that if we were to investigate questions of a deep-water coral diaspora, transatlantic studies were needed. Now, the pan EU-North American ecology of these deep water systems informs their spatial management. In the 1980s and 1990s research into cold-water corals was about the geological context. Now the focus has shifted and we are in the biological era asking questions like how do these systems work? How will they respond to various stressors? How can we protect them to ensure their survival? We couldn't begin to answer these questions without working across disciplines.

***TMB*: We are hearing about a new research centre; what is happening at Heriot-Watt?**

MR: The new Lyell Centre for Earth and Marine Science and Technology is a world-leading research cluster of earth and marine scientists. We were aware the British Geological Survey (BGS) needed to relocate, and I thought why not bring the earth science together with the marine science and technology of Heriot-Watt. The majority of the external funding has come from NERC and the Scottish Funding Council, now supplemented with additional grants from the Garfield Weston and Wolfson Foundations and Binks Trust. Heriot-Watt will be hiring up to 20 Professors and their teams, and the



The Logachev coral carbonate mounds on Rockall Bank. Image: Heriot-Watt University & NERC.

Centre's facilities include a 50,000 litre climate-controlled marine aquarium and suite of temperature-controlled rooms where water quality can be tightly controlled. Heriot-Watt already has facilities for robotics and sub-sea engineering and the Lyell Centre will also house the Marine Operations Unit for BGS, a unit well known for its autonomous engineering and world-leading deep rock drilling technology. The mantra for all the Lyell facilities is 'flexibility'. Working across disciplines is fundamental and the Lyell Centre will be housed in a building with a common core area to actively facilitate co-working between university and BGS staff.

TMB: Why is the Lyell Centre important for marine biology?

MR: Marine biology sits as a core discipline at H-W. Applied ecologists graduating from H-W are well-placed to address global change and energy issues and our alumni are in key positions in government, industry and NGO sectors around the world. I don't think we can do our best work as marine biologists in isolation – we need to team up with physicists, chemists, geologists, mathematicians and engineers to tackle the grand challenges of global change and ecosystem sustainability. That's what the Lyell Centre is all about.

***TMB*: How do you think scientific research can be made more accessible to the public?**

Entrance view of the new Lyell Centre. Image: Heriot-Watt University.

MR: There is certainly a role for advocates; we are tribal by nature and if the case for the oceans can be made by a well-known figure then it reaches more people and has more impact. A few years ago we wanted to refresh the Lophelia.org website and I was delighted when David Attenborough agreed to record a video to introduce deep-sea corals. People see a recognized face, trust the content and get drawn in to learn more.

But I think it's essential, and really good fun, to promote hands-on science experience. In 2012 I was chief scientist on a NERC-supported cruise as part of the UK Ocean Acidification programme. Through that programme I secured some extra funding to take local children from the Western Isles to sea to show them the deep water reefs off Mingulay. We partnered with Our Dynamic Earth here in Edinburgh and the children got to pilot the deep-sea ROV and talked one-on-one with scientists. It is important that amongst all the pressures there is space in a scientific career to do this sort of thing. It refreshes your outlook and broadens your horizons from the bread-and-butter of university research and teaching.

Local children flew the ROV on board the RRS *James Cook* during the 2012 Changing Oceans Expedition. Image: Heriot-Watt University & NERC.

***TMB*: Which areas of marine biological research do you think will be most important in the next 10 years?**

MR: The signature of warming and ocean acidification is so fast, it is very important we understand how ecosystems will acclimatize and adapt. And these changes are taking place throughout the ocean including in the depths of the sea where we lack even basic understanding of ecosystems and their dynamics. For example how do cold-water coral areas contribute to carbon turnover at regional and even global scales? Clearly these areas sustain high biodiversity and biomass but this is not built into ecosystem models. We need to discover and characterize what is down there and how it functions, which will take curiosity-driven research, *and* exploration. Applied in the right way technological revolutions in subsea robotics and engineering have real potential to explore and monitor change in the deep ocean, the largest marine ecosystems on Earth.

The new Lyell centre is due to open in January 2016.

Issue 6 of *The Marine Biologist*

The Marine Biologist

The magazine of the marine biological community

April 2016

www.mba.ac.uk/marinebiologist